Part 23—Airworthiness Standards: Normal, Utility, Acrobatic, and Commuter Category Airplanes

This change incorporates two amendments:

Amendment No. 23–44, Airworthiness Standards; Small Airplanes with Stall Speed Greater than 61 Knots, adopted July 7, 1993, effective August 18, 1993, in Federal Aviation Regulation Part 23. This amendment affects §§ 23.49, 23.67, and 23.562.

Amendment No. 23–45, Small Airplane Airworthiness Review Program Amendment No. 4, adopted July 28, 1993 (effective September 7, 1993), effects numerous sections in subparts B, C, D, G, Appendix D, and adds Appendix I.

Bold brackets enclose the most recent changed or added material in these particular sections. The amendment number and effective date of new material appear in bold brackets at the end of each affected section.

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Suggest filing this transmittal at the beginning of the FAR. It will provide a method for determining that all changes have been received as listed in the current edition of AC 00–44, Status of Federal Aviation Regulations, and a check for determining if the FAR contains the proper pages.

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MARKINGS AND PLACARDS

AIRPLANE FLIGHT MANUAL AND APPROVED MANUAL MATERIAL

Appendix A–Simplified Design Load Criteria for Conventional Single-Engine Airplanes of 6,000 Pounds or Less Maximum Weight

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Appendix C—Basic Landing Conditions

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Appendix E—Limited Weight Credit for Airplanes Equipped With Standby Power

Appendix F—Test Procedure

Appendix G—Instructions for Continued Airworthiness

[Appendix I—Seaplane Loads]

Special Federal Aviation Regulations

the United States. The small airplane airworthiness standards in this rule have been harmonized with those of foreign aviation authorities and will, in fact, lessen the restraints on trade.

Federalism Implications

The regulations herein will not have substantial direct effects on the States, on the relationship between the national government and the States, or on the distribution of power and responsibilities among the various levels of government. Therefore, in accordance with Executive Order 12612, it is determined that this regulation will not have sufficient federalism implications to warrant the preparation of a Federalism Assessment.

Conclusion

The FAA is revising the airworthiness standards for normal, utility, acrobatic, and commuter category airplanes as a result of comments received in reply to the Small Airplane Airworthiness Review Program Notice No. 3 dated October 3, 1990. The notice, which addresses powerplant and equipment items, was published as a result of recommendations discussed at the Small Airplane Airworthiness Review Conference held on October 22-26, 1984, in St. Louis, Missouri. Originally, the proposals reflected updated safety standards and advancements in technology while reducing the regulatory burden for some requirements and maintaining an acceptable level of safety. Harmonization with the European JAA Joint Airworthiness Requirements became a dominant factor after the close of the reopened NPRM comment period on August 21, 1991. Considerable effort was invested to harmonize these airworthiness standards because aircraft industry estimates indicate reduced overall certification costs. These airworthiness standards will continue to provide adequate levels of safety for small airplanes used in both private and commercial operations.

For the reasons discussed in the preamble, and based on the findings in the Regulatory Flexibility Determination and the International Trade Impact Analysis, the FAA has determined that this regulation is not major under Executive Order 12291. In addition, the FAA certifies that this regulation will not have a significant economic impact, positive or negative, on a substantial number of small entities under the criteria of the Regulatory Flexibility Act. This regulation is considered significant under DOT Regulatory Policies and Procedures (44 FR 11034; February 26, 1979). A regulatory evaluation of the regulation, including a Regulatory Flexibility Determination and International Trade Impact Analysis, has been placed in the docket. A copy may be obtained by contacting the person identified under "FOR FURTHER INFORMATION CONTACT."

The Amendment

Accordingly, the Federal Aviation Administration amends part 23 of the Federal Aviation Regulations (14 CFR part 23), effective May 10, 1993.

Authority: 49 U.S.C. 1344, 1354(a), 1355, 1421, 1423, 1425, 1428, 1429, and 1430; 49 U.S.C. 106(g).

those airplanes to have a stall speed greater than 61 knots, provided they meet certain additional occupant protection standards. These changes are needed to permit the design and type certification of higher performance airplanes with increased cruise speeds and better specific fuel consumption. The amendments are intended to achieve the benefits of certificating higher performance airplanes while affording their occupants the same level of protection in an emergency landing that is presently provided by airplanes with a 61-knot stall speed.

FOR FURTHER INFORMATION CONTACT: Mike Downs, Standards Office (ACE–112), Small Airplane Directorate, Aircraft Certification Service, Federal Aviation Administration, 601 East 12th Street, Kansas City, Missouri 64106; telephone (816) 426–6941.

SUPPLEMENTARY INFORMATION:

Background

This amendment is based on Notice of Proposed Rulemaking (NPRM) No. 91–12, which was published on May 13, 1991, (56 FR 22070). Comments to the NPRM were requested with a closing date of September 10, 1991. All comments received in response to Notice No. 91–12 have been considered in adopting this amendment.

DISCUSSION OF COMMENTS

General

Ten commenters submitted responses to Notice No. 91-12. One commenter objects to a statement made by the FAA in the background material of the notice. Five commenters favor the proposal and four commenters oppose the proposal.

One commenter objects to a statement in the background material of the notice and indicates that the FAA erred in stating that airplanes with a V_{SO} less than 61 knots and high wing loading would require complex high lift systems that may result in a reduction of low speed flying qualities and lessen the level of safety of both normal and emergency operations in approach and landing conditions. The commenter adds that complex high lift devices have been around since the late 1920's and many of the devices used at that time maintained excellent control down to and through stall speeds lower than 40 mph. The FAA is aware of these devices and some of the airplanes on which they are installed. The use of these devices may result in a reduction of the low speed flying qualities of the airplane. The pilot of an airplane equipped with a more complex high lift system may choose to land at a higher speed in normal operation to reduce piloting tasks. Another pilot may choose to land at a higher speed in an emergency situation in order to ensure ground impact under controlled conditions. At a higher approach speed, an airplane is less responsive to gusts, and the control of the airplane about all three axes is improved. In short, the handling qualities of an airplane are also dependent on the type and design of the high lift devices, and on the controls employed and the skill required to operate them.

One commenter argues that the current 61-knot stall rule does not account for advancements made in airplane engine reliability. The commenter states that, due to the increased reliability of airplane engines, the 61-knot stall requirement should be deleted. Another commenter indicates that the excellent airplane engine reliability record cannot be improved, and that a change in stall speed is not warranted. The FAA agrees that even though the probability of a powerplant failure may decrease with increased powerplant reliability, the probability of an emergency forced landing condition may remain constant or be minimally affected. As pointed out by the Small Aircraft Stall Speed Study Group, the predominant cause of emergency forced landings is fuel starvation caused by poor management or handling of the fuel system by the pilot. Since increased powerplant reliability has little effect on the number of emergency forced landings, the occupants of airplanes having a stall speed greater than 61 knots must be afforded the benefits of the same structural crashworthiness as those occupants in airplanes having a stall speed of 61 knots.

One commenter feels that this amendment and the 61-knot limitation have no relevance to commuter category aircraft and the contemplated value of peak acceleration level (32g) that the commenter believes is being considered for commuter category aircraft. The FAA agrees that this amendment has no relationship with the contemplated commuter category airplane NPRM for seats. The rationale used to provide an alternative to the 61-knot stall speed limitation is based partly on a methodology found in the U.S. Army's Aircraft Crash Survival Design Guide and in the comprehensive FAA/NASA full scale general aviation airplane impact test data base. The alternative to the 61-knot stall speed limitation is also consistent with the two analytical methodologies considered by the Simpson Crashworthiness Subcommittee. They emphasize and address crash and occupant inertia load attenuation.

This amendment adjusts the current combined vertical/longitudinal design standard found in the emergency landing dynamic conditions to require an increase in seat/occupant impact load attenuation that is consistent with the potential increase in impact acceleration level. The impact acceleration levels determined by the methods specified in this amendment are also consistent with the results of the full scale general aviation airplane impact test program.

The maximum acceleration levels found in this amendment are well within the survivability envelope for small airplanes found in the National Transportation Safety Board (NTSB) Phase III, General Aviation Crashworthiness Project Safety Report. The NTSB concludes that ''Acceleration levels and velocity changes of 23 to 30g and 50 to 60 feet per second in the vertical direction are generally survivable but the loads experienced by the occupants must be limited to a lower level to prevent crippling injuries to the back and neck''. This amendment is consistent with that conclusion and it should reduce or minimize spinal injuries since the amendment addresses crash and occupant inertia load attenuation.

One commenter suggests that a number of additional risks may be associated with the emergency landing. These risks should be addressed in this amendment and include the following: failure to avoid obstacles (aircraft maneuverability), failure of occupant restraints, failure of structure, failure of the pilot to execute the landing successfully (skill and training), and post impact fire.

Prior to issuing Notice No. 91–12, the FAA studied a recommendation to require additional flight instruction for pilots of single-engine airplanes with a power-off stall speed in the landing configuration of more than 61 knots. The FAA concluded that adequate flight instruction was already included in the normal flight training curriculum, though it did not relate specifically to an increase in stall speed. Pilot skill and training, including the ability to avoid obstacles, are covered adequately by the current flight training requirements.

The commenter does not provide supportive data or specific recommendations regarding failure of occupant restraints. However, occupant restraint and occupant impact load attenuation are addressed adequately by this amendment and by amendment 23–36 on emergency landing conditions (53 FR 30802; August 15, 1988).

The commenter does not cite a rationale or justify a need to address failure of structure. The FAA has no reason to extend this amendment to include enhancements to airframe structure. The airframe structures of all part 23 airplanes, including those that currently exceed the 61-knot stall speed limitation, are similar. There is no evidence to justify amending the airframe structure design standards at this time.

Finally, the JAA mentions their concern over the risks associated with post impact fire. The nature of post crash fires is difficult to define in terms of precisely where the fire starts and how it spreads. Clearly a prerequisite is the spillage of fuel followed by a source of ignition. Studies conducted by the General Aviation Safety Panel (GASP) indicate that existing data fails to identify precisely what advantages would accrue from increasing the crashworthiness of fuel systems in small general aviation airplanes. The purpose of improving the crashworthiness of a fuel system is to prevent considerable spillage in a survivable accident and delay the onset of rapid propagation of post crash fire in order to increase the time available for the pilot and passengers to remove themselves from the airplane. These improvements in crashworthiness may not in all cases prevent a post crash fire. GASP contends

Section 23.49

This proposes to amend part 23 of the Federal Aviation Regulations to permit type certification of both single and multiengine airplanes with stall speeds greater than 61 knots, provided they incorporate additional occupant protection provisions to compensate for the increased kinetic energy dissipated during a forced landing. This would be accomplished by amending § 23.49 to require compliance with certain additional occupant protection requirements included in this proposal.

Two comments were received on this proposal.

One commenter refers to the conclusion reached by the Small Aircraft Stall Speed Study Group. The study group found that it was impossible to conclude, based on the accident record, that the retention of the 61 knot stall limitation in part 23 for single-engine airplanes has provided any degree of crash protection to occupants. The commenter believes that this conclusion was made because the data related to airplanes that meet the present airworthiness standards.

The FAA notes that the Crashworthiness Subcommittee of the Small Aircraft Stall Speed Study Group found that "Increasing the stall speed, with no other stipulations, would increase the potential range of ground contact speeds in controlled emergency situations and would, therefore, increase the probability for serious injury." This subcommittee saw no valid reason for maintaining 61 knots or any other specified stall speed in part 23. The subcommittee concluded that if the 61-knot stall limitation is removed, a means should be incorporated to maintain a controlled emergency landing speed range. Since the ultimate concern should be to provide the airplane occupants with a reasonable probability of surviving a controlled crash situation, the subcommittee proposed crashworthiness criteria that would provide the level of safety previously achieved by the 61-knot stall speed limitation. The crashworthiness subcommittee examined two methodologies that address occupant crashworthiness protection. The methodologies used were based on an equivalent safety and an occupant survivability approach, and emphasized crash and occupant inertia load attenuation. However, the crashworthiness subcommittee did not pursue either of its approaches to a methodology that addressed occupant impact protection for an airplane that exceeds the 61-knot stall speed limitation. The subcommittee noted that definitive crash dynamic design standards for small airplanes did not exist at that time. Since the publication of the Small Aircraft Stall Speed Study Group report, emergency landing dynamic conditions have been adopted into FAR part 23, by amendment 23-36. This final rule extends the current emergency landing dynamic conditions specified in § 23.562 to small airplanes that exceed the 61-knot stall speed limitation. It provides crashworthiness criteria that addresses crash and occupant load attenuation.

One commenter indicates that airplanes having lower stalling speeds have lower fatal accident rates and points to recent statistics in the June 1, 1991, and June 15, 1991, edition of "Aviation Consumer," which indicates that the Cessna 172 and the Cessna 206/207 have the lowest fatal accident rate for four and six place single-engine airplanes. The commenter also indicates that there is a higher percentage of fatal emergency landing accidents for light multiengine airplanes compared to single-engine airplanes. This may support the conclusion that airplanes with higher stalling speeds also have higher fatal accident rates because typical multiengine airplanes usually have a higher stalling speed than typical light single-engine airplanes.

The Small Aircraft Stall Speed Study Group reviewed data consisting of 37,530 reports for the 6-year period from 1976 to 1981, which revealed the following: Emergency forced landings accounted for 14.7 percent of all accidents, representing 16.6 percent of single-engine airplane accidents and 7.2 percent of multiengine airplane accidents. Fatalities resulted from 2.6 percent of controlled emergency forced landings and 17 percent of uncontrolled emergency forced landings. For single-engine airplanes, these values were 2.1 percent and 13.4 percent, respectively, while for multiengine airplanes, these percentages were 8.5 and 34.2 percent, respectively. Therefore, the chances for a fatal emergency forced landing are much higher for a multi-engine airplane than for a single-engine airplane. However, a single-engine airplane is twice as likely to have an emergency forced landing as a multiengine airplane. Overall, between safety and landing stall speed cannot be found. This proposal is adopted as proposed.

Section 23.67

This proposal would clarify the change made to § 23.67 by amendment 23-42 (56 FR 344; January 3, 1991). The provisions of 23.67(b)(1) require that all reciprocating engine-powered multiengine airplanes with a stall speed of more than 61 knots meet the one-engine-inoperative climb gradient requirements. A change to § 23.67, paragraphs (b)(1) and (b)(2), is required to clarify that multiengine airplanes of less than 6,000 pounds maximum weight that meet the improved occupant protection requirements prescribed in § 23.562(d) and have a stall speed greater than 61 knots would comply only with the climb gradient determination requirements of § 23.67(b)(2)(i). This proposal does not change the one-engine-inoperative climb requirements.

No comments were received on this proposal and it is adopted as proposed.

Section 23.562

The supporting technical data used in the development of § 23.562 was obtained from small airplanes whose stall speeds were not greater than 61 knots. Airplane occupants were not exposed to increased levels of kinetic impact energy. The increase in kinetic impact energy, above the 61 knot stall speed baseline, is proportional to the square of the stall speed of the airplane in the landing configuration. To compensate for increased energy levels, additional occupant protection requirements beyond those stated in § 23.562 are included in this final rule. The emergency landing dynamic conditions express the impact energy level in terms of an impact velocity. The increased occupant protection requirement in this proposal is obtained by multiplying the ultimate load factors of § 23.561(b) and the peak deceleration of the seat/restraint system test of § 23.562(b)(1) by the square of the ratio of the increased stall speed to the stall speed of 61 knots. The use of the velocity ratio squared to obtain the increased occupant protection requirement is consistent with an analytical methodology found in the U.S. Army's Aircraft Crash Survival Design Guide, USARTL–TR–79–22C, Volume III—Aircraft Structural Crashworthiness, which addresses the conservation of momentum associated with an aircraft impact that has earth plowing.

The FAA is limiting the maximum deceleration for the seat/restraint system dynamic test to 32g, which is the value that the FAA is considering proposing in a separate NPRM being developed for commuter category airplanes. The 32g limitation will be reached at a stall speed (V_{SO}) of 79 knots. At a higher stall speed, this maximum deceleration remains constant at 32g.

In addition, the static upward ultimate load factor for acrobatic category airplanes will be limited to a value of 5.0g. Because of the maneuvers they perform, acrobatic category airplanes are designed to higher maneuvering limit load factors, both positive and negative, than normal and utility category airplanes. The maximum upward value required in this rule for normal and utility category airplanes is 5.0g. Under emergency landing conditions, all categories of small airplanes would experience similar forces; therefore, requiring acrobatic airplane seats to be designed to higher load factors would not be warranted.

A total of five comments were received on this proposal.

One commenter expresses doubt that occupant safety levels can be engineered to remain at current levels and any engineering reports that claim 15g survivability at 70–75 knots are seriously in question. The maximum acceleration found in this amendment is well within the survivability envelope for small airplanes found in the NTSB Phase III, General Aviation Crashworthiness Project Safety Report. The NTSB concluded in its safety report that survival from crashes where longitudinal loads ranged from 30 to 35g, with a velocity change of 60 to 70 feet per second and vertical loads ranging from 25 to 30g, with a velocity change of 50 to 60 feet per second, could be expected. The commenter suggests that the FAA review the NTSB's statistics on rates for light multiengine airplanes after ground impact. The commenter does not indicate what NTSB report is being referenced and what light multiengine rates are being reported. The commenter adds that existing light multiengine airplanes are already marginal performers and that increasing wing loading and speeds for the most critical segments of flight would

This is partially correct. If other conditions are unchanged, an increase in stall speed will probably result in airframes and occupants absorbing more energy on impact. However, with the development and adoption of emergency landing dynamic conditions into § 23.562 of the FAR by amendment 23-36, the current emergency landing dynamic conditions will be extended to those applicants who choose to design new airplanes with a stall speed greater than 61 knots. The extension of the current emergency landing dynamic requirements will provide crashworthiness standards that address load attenuation to the occupant. Furthermore, the results of the study conducted by the Small Aircraft Stall Speed Study Group, which consisted of the analysis of 37,530 accident reports over a 6-year period, failed to show a clear correlation between occupant survivability and landing stall speed. The commenter adds that airplane performance has not changed sufficiently in the last 50 years to warrant the proposed change. The commenter supports this with the commenter's own experience. The commenter then indicates that operator error is still the leading cause of aviation accidents and, since aircraft operators will continue to make mistakes, the existing stall speed requirement should remain, thereby protecting operators from themselves.

The commenter is correct that operator error is the leading cause of accidents. However, operator error and the need for improved pilot training are not airplane certification issues, and are beyond the scope of this rulemaking.

One commenter feels that the FAA was in error to assume that the NTSB data used to develop the emergency landing dynamic conditions for small airplanes was connected to the 61-knot stall speed. The commenter further asserts that most of the data in the NTSB data base were derived from airplanes that crashed under control at speeds in excess of 61 knots. The FAA disagrees. The conclusions found in the NTSB Safety Report "GENERAL AVIATION CRASHWORTHINESS PROJECT: PHASE III—ACCELERATION LOADS AND VELOCITY CHANGES OF SURVIVABLE GENERAL AVIATION ACCIDENTS, NTSB/SR–85/02" are contrary to those comments. In its analyses of airplane accidents, the NTSB relates the airplane impact speeds and respective acceleration levels to the stall speed of the airplanes. All but one of the thirty-nine small airplane accidents analyzed in the report were found to have a stall speed less than 61 knots.

Recent discussions with the NTSB personnel who compiled and analyzed all of the data in the three phase general aviation crashworthiness project also confirmed that, with few exceptions, all of the airplanes included in those studies had stall speeds that did not exceed 61 knots.

One commenter indicates that this amendment would require the means of retention of cabin mass items to be dynamically tested. The commenter also questions the different static ultimate design load factors for cabin mass items found in the emergency landing conditions for part 23 and part 25 airplanes. The FAA does not intend to require dynamic design or test standards for the retention of items of mass within the cabin. The ultimate design load factors for cabin mass items do indeed differ between part 23 and part 25 airplanes. They are representative of the expected emergency landing inertia load factors considering the respective airframe energy absorption characteristics and mass of those different category airplanes. Those differences were recognized and justified when the emergency landing dynamic conditions and respective amendments were adopted. Discussion and justification of those existing regulatory standards are not within the scope of this amendment.

One commenter proposes that the FAA limit the maximum stall speed to 70 knots, limit all the deceleration vectors according to the (stall speed/61 knots) ratio squared, multiply the impact velocity by the factor (V_{SO}/61), and amend § 23.787(c) regarding the forward ultimate load factor (9g) for luggage and cargo. This amendment addresses and satisfies the intent of these comments. The amendment increases the occupant impact protection level for those single-engine airplanes and certain multiengine airplanes with a stall speed that exceeds the 61-knot limitation.

The design standards found in this amendment remain within the limits of the small airplane impact survivability envelope. The commenter's proposal, however, could provide design standards that would be outside the small airplane's impact survivability envelope. Furthermore, the applicability and the feasibility the current velocity changes found in the emergency landing dynamic conditions are consistent with the survivability envelopes for small airplanes.

In addition, the commenter provides no justification to increase the inertia load requirements found in § 23.787(c). The commenter's proposal is considered beyond the scope of this amendment. However, the FAA is increasing the static design requirements for items of mass within the cabin, which include luggage and cargo, when the emergency landing dynamic conditions are adopted. Amendment 23-36 should meet the intent of the commenter's proposal. This proposal is adopted as proposed.

Paperwork Reduction Act

There are no reporting and recordkeeping requirements associated with this final rule.

Regulatory Evaluation Summary

This section summarizes the full regulatory evaluation prepared by the FAA that provides more detailed estimates of the economic consequences of this regulatory action. This summary and the full evaluation quantify, to the extent practicable, estimated costs to the private sector, consumers, Federal, State, and local governments, as well as anticipated benefits.

Executive Order 12291, dated February 17, 1981, directs Federal agencies to promulgate new regulations or modify existing regulations only if potential benefits to society for each regulatory change outweigh potential costs. The order also requires the preparation of a Regulatory Impact Analysis of all major rules except those responding to emergency situations or other narrowly defined exigencies. A major rule is one that is likely to result in an annual increase in consumer costs, a significant adverse effect on the economy of $100 million or more, a major increase in consumer costs, or a significant adverse effect on competition.

The FAA has determined that this rule is not major as defined in the executive order; therefore, a full regulatory analysis, which includes the identification and evaluation of cost-reducing alternatives to this rule, has not been prepared. Instead, the agency has prepared a more concise document termed a regulatory evaluation that analyzes only this rule without identifying alternatives. In addition to a summary of the regulatory evaluation, this section also contains the regulatory flexibility determination required by the Regulatory Flexibility Act (RFA) and an International Trade Impact Assessment. If more detailed economic information is desired, the reader may refer to the full regulatory evaluation contained in the docket.

Two comments were received concerning the economic aspects of this rulemaking. These comments were considered and no changes were made to the economic evaluation as a result of the comments. The reader is referred to the "Discussion of Comments" section above for more complete information.

Economic Evaluation

The FAA has determined that significantly more efficient airplanes could be developed by employing the advantages of higher wing loadings if the affected airplanes were not limited to a stall speed of 61 knots. The potential benefits of removing the stall-speed limit will vary with the mission of individual airplane designs, but case specific analysis has shown that a 20 percent gain in specific fuel consumption could be achieved. Evidence suggests that these high-wing-loading efficiencies could also be accomplished by incorporating a very high-lift flap system (wide-span trailing edge flaps and leading edge Kruger flaps) and still remain within the 61-knot limit. However, if higher wing loadings were combined with larger and more complex high-lift flap systems in order to meet the 61-knot requirement, there would be accompanying penalties in low speed handling qualities. These penalties would have a detrimental effect on both normal and emergency operations in approach and landing conditions.

In order to retain the current level of airplane occupant protection, this rule requires additional occupant protection for the airplanes that the rule allows to be certificated with stall speeds above 61 knots. Specific estimates of the potential structural and weight penalty costs that could be incurred are risk operating environment and by the additional structure required to support and deliver a large volume of liquid.

None of the petitions isolated the costs that would be incurred to meet the conditions attendant to their exemptions. Conversely, one applicant did estimate that the cost necessary to build an airplane with the same design mission without the exemption would be approximately 50 percent higher per unit.

The provisions afforded by the rule are optional and constitute an alternative to the existing requirement. By definition, this alternative, including any associated costs, will be exercised only by those applicants who have determined that it would be in their own best interests to do so. The rule provides the option of selecting the combination of stall speed and occupant protection enhancement that the applicant has determined would be most cost-beneficial and best suited for its particular airplane design. Therefore, the FAA finds that the potential benefits of this rule will exceed the expected costs.

Regulatory Flexibility Determination

The Regulatory Flexibility Act of 1980 was enacted by Congress to ensure that small entities are not unnecessarily or disproportionately burdened by Government regulations. The RFA requires a Regulatory Flexibility Analysis if a rule will have a significant economic impact, either detrimental or beneficial, on a substantial number of small entities. FAA Order 2100.14A, Regulatory Flexibility Criteria and Guidance, establishes threshold cost values and small entity size standards for complying with RFA review requirements in FAA rulemaking actions. The FAA has determined that this amendment to part 23 will not have a significant economic impact on a substantial number of small entities.

International Trade Impact Assessment

The provisions of this rule will have little or no impact on trade for both U.S. firms doing business in foreign countries and foreign firms doing business in the United States. In the United States, foreign manufacturers must meet U.S. requirements, and thus they will gain no competitive advantage. In foreign countries, U.S. manufacturers are not bound by part 23 requirements and could, therefore, implement the alternative provision afforded by the rule solely on the basis of competitive considerations.

Federalism Implications

The regulations adopted herein will not have substantial direct effects on the States, on the relationship between the national government and the States, or on the distribution of power and responsibilities among the various levels of government. Therefore, in accordance with Executive Order 12612, it is determined that this final rule does not have sufficient federalism implications to warrant the preparation of a Federalism Assessment.

Conclusion

The FAA is revising the airworthiness standards to permit single-engine and certain multiengine small airplanes of less than 6,000 pounds maximum weight to exceed the present 61-knot stall speed limitation. Airplane designs exceeding this limitation will be required to incorporate additional occupant protection to compensate for the higher kinetic energy that must be dissipated during emergency landings. This retains the current level of airplane occupant protection and permits the design and type certification of higher performance, single-engine airplanes capable of attaining an increase in cruise speeds with better specific fuel consumption. This improvement in performance and operating economics cannot be achieved without substantial increased cost and complexity if these designs are constrained by the present 61-knot stall speed limitation.

For the reasons discussed in the preamble, and based on the findings in the Regulatory Flexibility Determination and the International Trade Impact Analysis, the FAA has determined that this regulation is not major under Executive Order 12291. In addition, the FAA certifies that this regulation will not have a significant economic impact, positive or negative, on a substantial number of small entities under

The authority citation for part 23 continues to read as follows:

Authority: 49 U.S.C. 1344, 1354(a), 1355, 1421, 1423, 1425, 1428, 1429, 1430; 49 U.S.C. 106(g).

Amendment 23–45

Small Airplane Airworthiness Review Program Amendment No. 4

Adopted: July 28, 1993 **Effective: September 7, 1993**

(58 FR 42136, August 6, 1993)

SUMMARY: This amendment changes airframe and flight airworthiness standards for normal, utility, acrobatic, and commuter category airplanes. The changes are based on a number of recommendations discussed at the Small Airplane Airworthiness Review Conference held on October 22–26, 1984, in St. Louis, Missouri. These updated safety standards will continue to provide an acceptable level of safety in the design requirements for small airplanes used in both private and commercial operations. Some of the changes provide design requirements applicable to advancements in technology being incorporated in current designs. This amendment will also reduce the regulatory burden in showing compliance with some requirements while maintaining an acceptable level of safety.

FOR FURTHER INFORMATION CONTACT: Kenneth W. Payauys, Aerospace Engineer, Standards Office (ACE–110), Small Airplane Directorate, Federal Aviation Administration, 601 East 12th Street, Kansas City, Missouri 64106, telephone (816) 426–5688.

SUPPLEMENTARY INFORMATION:

Background

On June 15, 1990, the FAA issued a notice of proposed rulemaking (NPRM) that proposed changes to the airframe and flight airworthiness standards for normal, utility, acrobatic, and commuter category airplanes (Notice No. 90–18, 55 FR 26534, June 28, 1990). The FAA based the proposed changes on the Small Airplane Airworthiness Review Program and on the conference that resulted in recommendations based on review proposals.

History

To encourage public participation in improving and updating the airworthiness standards applicable to small airplanes, the FAA announced the Small Airplane Airworthiness Review Program on January 31, 1983, and invited all interested persons to submit proposals for changes to part 23.

By the close of the proposal period on May 3, 1984, the FAA had received more than 560 proposals. On October 22–26, 1984, the FAA held the Small Airplane Airworthiness Review Program Conference in St. Louis, Missouri. The conference was attended by over 300 persons representing all aspects of the U.S. small airplane industry as well as many international representatives. A copy of the transcripts of all discussions held during the conference is filed in FAA Regulatory Docket 23494.

After reviewing the proposals and the public comments received at the conference, the FAA issued a number of rulemaking documents. These include:

(1) A notice proposing to upgrade cabin safety and occupant protection standards during emergency landing conditions (Notice 86–19, 51 FR 44878, December 12, 1986), which led to amendment 23–36 (53 FR 30802; August 15, 1988).

1993).

The review program and conference also led to the proposal for this rulemaking action, which updates the airframe and flight airworthiness standards for small airplanes.

The FAA is participating in an important international effort to harmonize part 23 of the Federal Aviation Regulations (FAR) with the Joint Aviation Requirements (JAR) developed by representatives of the Joint Aviation Authorities (JAA). This final rule is a significant step in the harmonization effort, which is being encouraged and supported by the aviation community worldwide.

DISCUSSION OF COMMENTS

General

Interested persons were invited to participate in the development of this final rule by submitting written data, views, or arguments to the regulatory docket. Eight commenters responded to Notice No. 90–18. Commenters represent U.S. manufacturers of small aircraft (General Aviation Manufacturers Association, GAMA), Joint Aviation Authorities, JAA, individual airworthiness authorities (United Kingdom, Australia, Transport Canada), the Air Line Pilots Association (ALPA), a representative of the Association of Europeene des Constructeures des Material Aerospatial (AECMA), and one private individual. Most commenters either endorse other comments or comment on only a few of the proposed changes. GAMA comments on a significant number of the proposed changes and JAA comments on virtually every proposed change. AECMA submitted a one-sentence comment endorsing the GAMA comment.

One commenter (ALPA), while supporting "the fundamental intent" of the NPRM and applauding "the FAA for the work and progress" from the 1984 conference, also states a belief that there is a need for a "single regulation to prescribe that all part 25 certification aircraft are used by scheduled commercial airlines."

In general, the commenters agree with the proposed changes and one commenter (GAMA) urges the FAA to issue a final rule as expeditiously as possible.

In the NPRM, the FAA specifically solicited comments on the following subjects:

Conference Proposal 2, § 23.3, Permit installation of turbojet engines on commuter category airplanes.

Conference Proposal 7, § 23.65, Require performance limitations based on weight, altitude and temperature.

Conference Proposal 10, § 23.145, Establish control force limits for reduced pilot strength, and

Conference Proposal 29, § 23.307, Require material correction factors during structural tests.

The first two subjects listed above are subjects on which the FAA solicited comments for future rulemaking. No final action is taken in this rulemaking on these two subjects. The discussion of comments on these two subjects follows the proposal-by-proposal discussion at the end of the supplementary information section of this preamble. The second two subjects relate to rulemaking proposal number 10 (§ 23.145) and rulemaking proposal 29 (§ 23.307). Discussion of comments for these subjects is contained in the proposal-by-proposal discussion.

Discussion of Comments on Specific Sections of Part 23

As stated above, the majority of the specific comments were received from the GAMA and the JAA. In the following proposal-by-proposal discussion, the basic intent of each proposed change is summarized and substantive comments are addressed individually. Comments and changes of an editorial nature are generally omitted from the discussion.

In this final rule, the FAA has withdrawn a total of three proposals from the NPRM and is amending (for clarification) two sections for which changes were not proposed in the NPRM. The withdrawal

68	Not Adopted
69–72	69–72
73	Not Adopted
74–83	73–82
Appendix H	Appendix I

Proposal 1. This proposal contained the authority citation for part 23, for which there was no change.

Proposal 2. The FAA proposed a change to § 23.23 that specified the limits for load distribution for weight and balance considerations. The one comment (JAA) received generally agrees with the proposed change but does not agree that the specific reference to lateral center of gravity (c.g.) range limits should be deleted. Also, the JAA does not believe (1) that the proposal treats lateral c.g. consistently and (2) that there is a need for all of the required flight test evaluation with displaced lateral c.g. limits. The JAA notes that requiring all testing to be repeated with fuel asymmetry is unnecessary and impractical but that it would be appropriate to take fuel asymmetry into account for some tests such as minimum control speeds, stall handling, and lateral stability.

The FAA agrees that deleting specific references to lateral c.g. limits may not be appropriate and has revised § 23.23(a) to retain lateral load limits in the regulations. The FAA disagrees that the proposal treats lateral c.g. limits inconsistently. Repeating all testing with fuel asymmetry is unnecessary to find compliance. Accordingly, the FAA adopts § 23.23 with the change discussed above.

Proposal 3. The FAA proposed a change to § 23.25 to clarify the criteria used for assuming occupant weights in normal, commuter, utility, and acrobatic category airplanes. The proposed change would no longer permit the certification of normal category airplanes with seats placarded for occupants of less than 170 pounds. Seats limited to some lower weight by the placard installation will be referred to as ''child seats'' in the remainder of this discussion.

The GAMA and JAA commented on this proposal. The GAMA opposes deleting the provision that allows for the installation of child seats. The GAMA notes that existing provisions of § 23.25 allow the manufacturer to install child seats and establish proper loading provisions for the airplane. GAMA believes that deleting this provision would operationally limit future airplanes. The GAMA also notes that several unacceptable alternatives could result from the proposed deletion, such as carrying less fuel, installing fewer seats, and carrying less safety equipment. The GAMA feels that child seats in airplanes fulfill a consumer need. The GAMA does not agree with the FAA's statement in the NPRM that the lack of specific standards for child seats is appropriate justification for disallowing placarding of child seats. The GAMA states that seat rules can be changed to certify fixed child seats at selected weight limits.

The JAA states that it does not understand the FAA's reasoning for disallowing child seats in normal category airplanes.

The FAA reconsidered this proposal, based on these comments, and agrees that eliminating the approval of child seats in normal category airplanes is inappropriate. However, the FAA points out that future rulemaking to provide safe standards for child seats will be needed in view of changes to § 23.562 made by amendment 23–36 (53 FR 30802, August 15, 1988), which established a safety level for occupants with a nominal weight of 170 pounds.

Although the FAA will allow the installation of child seats, placarding pilot seats for occupants weighing less than 170 pounds or 190 pounds, depending upon airplane category, will not be allowed because there is no reason to do so. Accordingly, a revision to § 23.25(a)(2) ensures that pilot seats are not placarded for a reduced weight.

The GAMA also pointed out that the minimum fuel requirement of ''at least one-half hour'' in § 23.25(a)(2)(i), which is a part of the requirement for computing the minimum or maximum weight, is inconsistent with the fuel requirements of part 91. Section 91.151, Fuel requirements for flight in turbine engine/propeller combinations and other requirements applicable to turbopropeller-powered airplanes not covered by the present rule.

The FAA received comments from the JAA and the GAMA. Both commenters questioned the need to add requirements for turbopropeller-powered airplanes (proposed paragraphs (b)(1)(ii) and (b)(2)(ii)) since it is unlikely that a fixed-pitch propeller will be used on a turbine-powered engine.

The FAA has re-examined these proposals and determined that proposed paragraphs (b)(1)(ii) and (b)(2)(ii) are not necessary.

The GAMA states that the proposal for § 23.33(d)(2)(ii) will allow a 2,700 r.p.m. engine to operate at 2,940 r.p.m., or higher, if the governor should fail and that this change does not appear to be in the interest of safety. The FAA is not making any change to the proposed requirement because the information contained in the comment is insufficient. The NPRM documents that there are usually two governors in an engine/propeller system, one controlling the propeller rotational speed and one controlling the overspeed of the turbine engine. This explanation notes that if the propeller governor fails, the overspeed limit will be established by the turbine governor and probably will be 106 to 108 percent. The condition identified by the GAMA is nearly the same as the condition identified in the notice (2,940 r.p.m. is a 108.9 percent overspeed of 2,700 r.p.m.). The GAMA appears to support proposed § 23.33(d)(2)(ii) that would have required a means to limit the engine overspeed to 99 percent of the approved engine overspeed.

The FAA recognizes that a fuel control governor usually controls turbine engine overspeed Any required margin (such as the proposed 1 percent) would be considered during the establishment of the approved overspeed. Accordingly, it burdens the applicant to require an additional device that arbitrarily limits overspeed to 99 percent. By removing the 99 percent requirement, § 23.33(d)(2)(ii) allows full approved overspeed. The FAA adopts § 23.33 with the changes discussed above.

Proposal 5. The FAA proposed to clarify the performance data requirements of § 23.45 and to combine the requirements for reciprocating and turbine-engine-powered airplanes. Since the one comment received from the JAA agreed with the proposed change, the FAA amends § 23.45 as proposed.

Proposal 6. The FAA proposed to change § 23.53 to introduce a rotation speed, V_R, for multiengine airplanes and to eliminate reference to V_X (speed for the best angle of climb) for airspeeds at 50 feet. The FAA received comments on this proposal from the JAA and the GAMA.

The JAA notes that the reference to 1.3 V_{S1} (stalling speed or minimum steady flight speed in a specific configuration) in proposed §§ 23.53(b)(1)(ii) and (b)(2)(ii) is unnecessary and suggests clearer wording for the proposed change. The proposed language that states, "not less than 1.2 V_{S1}," establishes the minimum V_{S1} speed that must be reached by a height of 50 feet above the takeoff surface. The JAA recommends revising the language to read, "1.2 V_1, or any other speed shown to be safe . . . ." The FAA rejects this suggestion because it would allow the use of a speed below 1.2 V_1, which the FAA considers the minimum acceptable margin above the stall speed at the 50 foot point.

The GAMA recommends deleting the words "including turbulence" in proposed § 23.53(b)(1)(ii) and (b)(2)(ii). The GAMA believes that considering turbulence deviates from the intent of the general requirement of § 23.45 that requires still air performance corrections in a standard atmosphere.

The commenter is partly correct. Most of the performance testing can be done in still air under standard atmospheric conditions, but some tests need to be done under other conditions. Thus, § 23.53 requires turbulent conditions for some, but not all, testing to find safe minimum takeoff speeds. Accordingly, these words are not being deleted from § 23.53(b)(1)(ii) and (b)(2)(ii).

The GAMA also asks why turbulence is considered for normal, utility, and acrobatic category airplanes and not for commuter category airplanes.

discussed above.

Proposal 7. The FAA proposed to delete from § 23.65 the current rate-of-climb requirements and to specify a minimum speed at which the angle-of-climb criteria must be met. The FAA received comments on this proposal from the JAA, GAMA, and ALPA. As previously discussed, the portion of the JAA, GAMA, and ALPA comments that address the subject of weight, altitude, and temperature (WAT) requirements for part 23 airplanes is discussed following this proposal-by-proposal discussion.

The GAMA states that the FAA has not justified the proposed change to § 23.65(a)(1) for a minimum all-engine-climb speed of 1.2 V_{S1} and that this restriction appears unnecessary because V_X is usually greater than 1.2 V_{S1}. GAMA notes that, if V_X is lower, any questions resulting from attitude and engine failure can easily be dealt with in the flying quality rules.

The JAA believes that the proposed minimum climb speed of 1.2 V_{S1} (stall speed or minimum steady flight speed obtained in a specific configuration) offers an inadequate stall speed margin for an everyday all-engines-operating case and recommends not less than 1.2 V_{MC} (minimum control speed with critical engine inoperative) or 1.3 V_{S1}. The GAMA states that the FAA has not justified the proposed minimum all-engine-climb speed of 1.2 V_{S1}.

As presented in the NPRM, the FAA finds that 1.2 V_{S1} is an improvement in the minimum performance standards. Deleting climb rate requires considering a minimum speed to ensure an adequate margin between stall speed V_S and the selected climb speed. If V_X is usually greater than 1.2 V_1, as the GAMA states, then rule compliance is not a burden. If V_X is lower than 1.2 V_1, then V_X provides an insufficient margin with stall speed which cannot be dealt with in the flying quality rules. This position is supported by another commenter. The FAA concludes that 1.2 V_{S1} is adequate and that a V_{MC} based requirement is unnecessary. The FAA adopts § 23.65 as proposed.

Proposal 8. The FAA proposed to change § 23.141 to clarify the general requirements for flight characteristics.

The one commenter (JAA) agrees with the proposal but suggests some changes for the paragraph. The first is to insert the phrase "at all practical loading conditions" so that the section will read "through § 23.253 at all practical loading conditions, at all practical operating altitudes."

The FAA notes that the current evaluation of an airplane's flight characteristics must consider all practical loading conditions in accordance with § 23.21. This addition does not add a requirement to flight characteristic testing and does clarify the requirement. The final rule paragraph adds this phrase.

The other suggested change proposes to add a phrase between "under § 23.1527" and "without exceptional piloting skill," which reads, "for which certification has been requested." The FAA agrees and has added the phrase to the final rule. The phrase clarifies that the loading condition and altitudes, checked during the flight characteristics evaluation, are those conditions and altitudes requested by the applicant for approval. The FAA adopts § 23.141 with the changes discussed above.

Proposal 9. The FAA proposed to change § 23.143 by replacing the word "Dive" with the word "Descent" because descent more accurately reflects the total phase of flight. No one commented on this proposed change, and the FAA adopts the change to § 23.143 as proposed.

Some comments received on § 23.145 resulted in revisions to the table in § 23.143(c). These comments are discussed in the discussion of § 23.145.

Proposal 10. The FAA proposed to change § 23.145 to correct an error created by amendment 23–21 and to correct the trim speeds and procedures.

Although the FAA received no comments on paragraph (a) of § 23.145, the FAA notes that "the airplane as nearly as possible in trim at 1.3 V_{S1}" is a condition specified for both maximum continuous

The JAA provides extensive comments on § 23.145(b). First, the JAA asks to what the 50-pound control force limit of § 23.145(b) applies. The JAA believes that this force should include any initial out-of-trim force and the change of control force that occurs during the variations in flight conditions. As proposed by the FAA, this requirement does not determine the total control force on the airplane during the maneuvers specified in § 23.145, paragraphs (b)(1) through (b)(5). The one-hand control force test verifies that the changing control forces, during the maneuver, do not become higher than the pilot can safely control. The FAA specifies a one-hand control force because, during the maneuvers, the pilot is using one hand to change the power settings or flap positions. Only one hand will be available to correct the resulting control force changes. Accordingly, the requirement for the airplane control force is not limited to a total of 50 pounds, as the JAA advocates. The requirement allows force to be the sum of the initial out-of-trim force plus the allowed 50 pounds to correct the maneuver. In practice, the total control force on the airplane depends upon the direction of the pilot force and the direction of the initial out-of-trim force. The out-of-trim forces may add (or subtract) to the 50-pound control force limit.

The JAA also recommends deleting the words "the gear extended" from § 23.145(b) since the demonstration required by paragraphs (b)(3) and (b)(4) are with gear retracted.

The FAA re-examined these requirements and agrees that the gear position requirements of § 23.145(b) conflict with § 23.145, paragraphs (b)(3) and (b)(4). But, the FAA does not agree that the gear position requirement of § 23.145(b) should be deleted. It is necessary to specify the needed gear position in the maneuvers in § 23.145, paragraphs (b)(1) through (b)(5). To correct these requirements, the FAA removes the words "with the landing gear extended" from § 23.145(b) and adds this phrase to § 23.145, paragraphs (b)(1) and (b)(2).

The JAA also believes that proposed § 23.145(b)(2)(i) fails to address properly a normal balked landing demonstration. First, the JAA notes that the proposed initial trim speed of 1.2 V_{SO} (stalling speed or minimum steady flight speed in landing configuration) is below the final approach speed of 1.3 V_{SO}. Second, mishandled balked landings are covered in § 23.145(b)(2)(ii). Third, it is incorrect to require a speed abuse for the normal demonstration requirements.

The JAA also disagrees with the proposal to require the airplane to maintain the speed used to show compliance with § 23.77. The JAA's reasons for disagreeing are that § 23.77 provides requirements for the balked landing climb case, and it is inappropriate to correlate this climb condition to those for the balked landing demonstration of § 23.145(b)(2)(i), which recommends go-around settings. To support not using the speed of § 23.77, the JAA notes that it could be as low as 1.1 V_{SO}, which is not a realistic go-around speed with flaps partly retracted. The JAA recommends a speed of 1.3 V_{SO}.

Finally, the JAA disagrees with the reference to § 23.145(b)(1)(i) in proposed § 23.145(b)(2)(iii) because there should be no flap gate positions between fully extended and go-around flaps. The JAA agrees with giving credit for the flap gate positions in the mishandled balked landing requirements of § 23.145(b)(2)(ii), but questions the need to maintain a speed of 1.1 V_{SO}. The JAA believes that it is acceptable to retrim between each gate stage of flap retraction and that it should be acceptable to allow the airplane to accelerate to 1.1 V_{S1}, where V_{S1} is the selected flap setting configuration.

The FAA has reviewed the proposal in light of the comments received on § 23.145(b) concerning airplane trim at 1.2 V_{SO} or 1.3 V_{SO} and agrees that an abuse speed of 1.2 V_{SO} for a normal balked landing is inappropriate. The final rule allows an abuse speed of 1.3 V_{SO} for a normal balked landing. However, the FAA considers an abuse speed of 1.2 V_{SO} appropriate for a mishandled balked landing.

The FAA does not agree that it is inappropriate to correlate the balked landing climb in § 23.77 to the balked landing of § 23.145(b)(2)(i). The FAA has evaluated this and determined that a speed showing compliance with the balked landing climb is also safe for a wings level go-around flight. Changes to § 23.77 clarify that the balked landing speed is the minimum speed that must be maintained.

The JAA concurs with § 23.145, paragraphs (b)(3), (b)(4), and (b)(5), and suggests moving § 23.145(b)(5) to § 23.175 and combining it with § 23.175(d). The FAA reviewed the possibility of combining these two sections, which would require revisions in both. This could create unintended meanings, and since the recommended changes are beyond the scope of the notice, the FAA will consider this proposal for future rulemaking.

Both the GAMA and the JAA offer comments on proposed § 23.145(c). The GAMA notes that this requirement would require a demonstration of an elevated load factor, and suggests that, for reasons of safety, this should be an extrapolation of lower speed data or an analytical finding. The JAA states that the JAA is unclear on the relationship of this proposal to present § 23.335(b)(4)(i) and suggests a paragraph revision that would reference § 23.335(b)(4)(i).

Proposed § 23.145(c) requires a demonstration of 1.5g pitch maneuver capability up to V_D/M_D (design dive speed/design dive Mach number). The demonstration is necessary and should not be extrapolated from a lower speed test. Calculations may be used to show compliance with § 23.335(b)(4)(i). It is inappropriate to combine the design airspeed with the proposed § 23.145(c) flight demonstration. Also, showing compliance with § 23.335(b)(4)(i) by flight demonstration fails to explore the pitch maneuver capabilities close to V_D/M_D. The FAA adopts § 23.145(c) as proposed.

The JAA questions the need for the c.g. conditions contained in § 23.145, paragraphs (d)(1) and (d)(2). Section 23.21 covers these conditions. The FAA's review shows that the specific reference to the c.g. position is unnecessary, and deletes it. The FAA adopts § 23.145 with the changes discussed above.

Proposal 11. The FAA proposed changing § 23.147 to delete the existing § 23.147(a), to renumber the remaining requirements, and to delete references to center of gravity.

Since the only comment, from the JAA, agrees with the proposed change, the FAA adopts § 23.147, as proposed.

Proposal 12. The FAA proposed to define airworthiness standards for determining the minimum control speed and to reword particular portions of § 23.149 for clarity.

The FAA received comments from the JAA and the GAMA, on § 23.149. Only the JAA addressed the proposed revised definition of V_{MC} in § 23.149(b)(2). The JAA objected to the proposal to change the words "recovering control" to "maintaining control." The FAA intended this proposed revision to eliminate any implication that control is lost when the engine fails. The JAA feels the proposed change is "ill-advised" because the demonstration of V_{MC} results in an airplane handling excursion, in all three axes, followed by a recovery. The JAA identifies the continued use of the word "recovery" in the stall requirements to support this position.

The FAA considered the JAA's comments, and the conference discussion, and concludes that the term "recovering" should not be used. Though excursions may occur in all three axes, those excursions do not mean that complete loss of control of the airplane has occurred. "Maintaining control" includes the action needed to correct these excursions and to continue to fly the airplane with one engine inoperative. It is appropriate for use in this definition. This revision in the V_{MC} definition should not be considered for extension to the stall requirements. Control is lost in a stall; therefore, the term "recovery" is appropriate for the stall requirements.

The JAA also states that the NPRM phrase, "with a yaw of not more than 20 degrees," in the proposed definition of V_{MC} is confusing, since heading excursions are limited to 20 degrees in unchanged § 23.149(d).

The FAA has reviewed this proposed change, along with the text of § 23.149(d), and agrees that the proposed revision does not provide the intended improvements. Accordingly, it is removed in this final rule.

minimum values proposed and believes that these limits are so small that they defeat the purpose. The JAA does not agree with the establishment of V_{SSE} as a limitation.

The FAA has considered these comments and agrees with the expressed position that V_{SSE} should not be established as a limitation. The FAA is aware of the benefits resulting from informing the pilot of the speed that provides an additional safety margin above V_{MC}. This is especially important in a training environment. Accordingly, § 23.149(c) is revised to require that V_{SSE} must be established and a new § 23.1585(c)(6) requires that this information must be put in the AFM. By establishing this requirement, information recommended by GAMA's Specification No. 1 can be included in the AFM. The FAA adopts § 23.149 with the changes discussed above.

Proposal 13. The FAA proposed changes to the landing control requirements in § 23.153. The FAA received comments from the JAA and the GAMA on this proposal.

The GAMA believes that the FAA may have overlooked the effect that the proposed change would have on airplanes weighing 6,000 pounds or less which are not required to meet § 23.153. For these airplanes the GAMA believes that the speed for control during landing should be set in a different way than using the speed used for the demonstration of landing under § 23.75, minus 5 knots.

The FAA disagrees. The FAA considered all airplane weights in the NPRM. Existing § 23.75 does not differentiate landing speed by weight.

The GAMA states that § 23.153(b) adds the steepest approach gradient for landing control. The GAMA believes that the approach gradient is inappropriate because there is no practical way for a pilot to determine the gradient.

The FAA notes that part 23 already requires a pilot to determine the gradient. Section 23.75(a), as amended by amendment 23–42, requires landing distance to be determined for all airplanes. The section also requires that the distances be based on a descent gradient of 5.2 percent at not less than a 1.3 V_{S1} speed. Additionally, an applicant may show a steeper approach gradient if a means is available to display gradient to the pilot.

The JAA states that the proposed changes to § 23.153 bring the requirement substantially into line with JAR 23.153. JAA also concurs with the inclusion of all airplanes and with the inclusion of proposed paragraphs (b) and (c). The JAA states that it is "disturbed that the cross-reference to § 23.143(c) could allow the use of a (two-handed) elevator control force as high as 75 pounds in a landing maneuver."

The FAA agrees with the JAA. To clarify the FAA's intent, final rule § 23.153 specifies a one-handed force. The FAA adopts proposed § 23.153, with this change.

Proposal 14. The FAA proposed to change § 23.155 to clarify the conditions used to prove elevator control force.

The JAA submitted the only comment on this proposal, stating its preference for existing § 23.155(b)(2). Also, the JAA states that, if the FAA retains § 23.155(b)(1) as proposed, the words "for level flight" should be changed to "for wings level flight."

The FAA agrees that "for wings level flight" clarifies "level flight condition" and has, therefore, changed the final rule accordingly. In evaluating the suggestion to add the word "wings", the FAA notes that the current § 23.155(b)(2), which this proposal is replacing, uses the words "with wings level." Adding the word "wings" will retain the previously used language. Since the proposals for § 23.155(b)(1) and (b)(2) also contain the words "level flight," the suggested change is also made to these paragraphs. The FAA adopts § 23.155, with the changes discussed above.

Proposal 15. The FAA proposed to add a ten-second limit to the equation in § 23.157(a)(2) and a seven-second limit to the equation in § 23.157(c)(2). These proposed limits would restrict all airplanes

The comment from the JAA agrees with the proposed change to the required power for reciprocating engines. However, the JAA does not believe that the phrase "or the maximum power or thrust selected by the applicant as an operating limitation for use during cruise . . ." is appropriate. The JAA believes that this limitation can be abused and asks how it should be interpreted in comparison with, for example, maximum continuous power or thrust, if the latter is greater. The JAA notes it is considered unreasonable to "get around" the requirement by declaring a "limitation" while claiming credit for a higher maximum continuous limit under other circumstances. Also, the JAA notes other requirements in part 23 using similar words referring to limits for cruise or climb operations.

The first item addressed by the JAA is that this limitation can be abused; the FAA agrees. This is true of most limitations placed on an airplane. Engine power or thrust limitations are no more likely to be abused than any other limitation. An important aspect of safety in the aviation community is the training of pilots and their understanding that limitations are established to avoid possible unsafe conditions. The FAA does not find the JAA's reasons adequate to change the proposed requirements that would permit the establishment of limitations.

The other JAA position, that limitations are established to allow the holders of a type certificate to "get around" certain other provisions of the requirements, is not valid. There are circumstances, such as where an airframe manufacturer needs to replace the engine on a particular airplane model and the only engine available produces more horsepower than the engine that was originally approved for that airframe. By using the higher powered engine, and establishing limitations, it may be possible to obtain approval without incurring the additional expenses of redesign and testing that would otherwise be needed for using a higher power engine. The regulations permitting the establishment of limitations benefit the public by reducing costs. No known adverse affects on safety have resulted from these provisions.

The JAA also noted that the present § 23.175(d)(3) contains a reference to § 23.161(c)(4), which does not exist. A review of the regulations shows that some publications do reference § 23.161(c)(4) while other publications correctly reference § 23.161(c)(2).

To verify the correct paragraph that should be referenced in § 23.175(d)(3), the FAA reviewed the history of both §§ 23.161 and 23.175. Before the adoption of amendment 23–21 on March 1, 1978, § 23.161 requirements for power approaches were contained in § 23.161(c)(4), and § 23.175(d)(3) correctly referenced in § 23.161(c)(4). When the FAA adopted amendment 23–21, it revised the trim requirements and moved the power approach requirements to § 23.161(c)(2). Amendment 23–21 also revised § 23.175(d)(3) to correctly reference § 23.161(c)(2). This error needs to be corrected in the current publications and, while not included in the NPRM, is included in this final rule.

The FAA adopts § 23.175 with the change discussed above.

Proposal 17. The FAA proposed to revise § 23.177(a) to require that static directional stability and lateral stability be shown under more realistic operating conditions expected in service. Changes proposed to § 23.177(a)(1) revise the approach configuration to be used to evaluate the static directional stability. Instead of the maximum continuous power previously required, the engine power necessary to maintain a three degree angle of descent is now specified. Proposed revisions to § 23.177(a)(2) require static lateral stability in the landing configuration at the engine power necessary to maintain a three degree angle of descent. Presently, 75 percent maximum continuous power is used. In addition, the proposal would have deleted the current rule requiring a bank angle of 10 degrees or more.

The JAA and the GAMA address § 23.177(a)(1). The JAA states, "We do not agree with the proposed relaxations in minimum speed (in configurations other than takeoff) and maximum power in the landing configuration for demonstrating positive directional stability." The JAA believes that directional instability is an undesirable characteristic and should not be permitted within, or outside, the normal flight envelope, and that 1.2 V_{S1} is a reasonable lower speed for all configurations. The JAA also states that power settings above that needed for approach are reasonable in the landing configuration, for example, during

The GAMA states that § 23.177(a)(1) needs to be clarified. The GAMA states that the proposed language calls for a demonstration at 1.2 V_{S1} for the takeoff configuration and at 1.3 V_{S1} for climb, cruise, and approach configurations in the same sentence. The GAMA states that the next sentence addresses the "landing configuration" (normally a power-off case) as having power to maintain a three degree angle of descent (usually the approach case). The GAMA asks whether the word "landing" should be replaced with the word "approach" for the latter demonstration.

The FAA has determined that, contrary to the GAMA assumption, "landing" is the correct word and as the rule states some power is required in the landing configuration to maintain a three-degree angle of descent. This agrees with the configuration and power in proposed § 23.75.

The GAMA notes that the NPRM proposes showing directional stability "at speeds from 1.2 V_{S1} in the takeoff configuration and 1.3 V_{S1} in other configurations . . . ." The GAMA states that rudder force reversal (in the same paragraph) is prohibited "from V_{S1}" with no configuration distinction and asks if these are compatible.

The FAA agrees that the rule, as proposed, gave speed ranges that were not compatible. As noted earlier, § 23.177(a) adopts the speed of 1.2 V_{S1} as the lowest for all configurations and this change eliminates the incompatibility. The FAA adopts § 23.177(a)(1) with the changes discussed.

The JAA comment on proposed § 23.177(a)(2), states "we see merit in retaining the existing 10° bank criterion, to define slip angle, provided that a rudder force of 150 lbs. is not exceeded." Section 23.177(a)(2) is adopted as proposed.

However, the JAA also believes that the proposed relaxation in power for the landing configuration demonstration is ill-advised and that the airplane could be laterally unstable in a go-around.

The FAA agrees that relaxation of the engine power requirements could result in lateral instability in a go-around. However, since go-around is a transitory condition where the pilot normally makes prompt changes to the airplane configuration, there is no need for the regulations to address higher engine power in the landing configuration.

Concerning the proposed § 23.177(a)(3), the JAA questions two points. First, in the sentence, "At larger slip angles up to the angle at which full rudder and aileron control is used . . .," the JAA believes that the wording should read "full rudder or aileron." The JAA also believes it is unlikely that rudder and aileron limits would be reached together in a steady sideslip maneuver. Second, the JAA questions the meaning of the sentence, "Enough bank must accompany the sideslip to hold a constant heading." The JAA believes clarification is necessary.

The FAA agrees that the word "or" between the words "rudder" and "aileron" clarifies § 23.177(a)(3). Concerning the second point, the FAA has applied this rule for several years without any questions about its intent or manner of performing the maneuver. The FAA adopts § 23.177(a), with the changes discussed above.

Proposal 18. The FAA proposed to remove § 23.179, Instrumented stick force measurements. Since the FAA received only one comment from JAA, which agrees with the proposed change, the FAA is deleting § 23.179, as proposed.

Proposal 19. The FAA proposed to revise § 23.181 to account for installed stability augmentation systems, and to require an evaluation of the airplane for phugoid-type oscillations. The FAA received comments on this proposal from the JAA and the GAMA.

The JAA notes that part 25 requires stability and augmentation systems and § 25.181 "does not include the relaxation in stick fixed dynamic stability demonstrations offered by the proposed change to FAR 23.181". JAA apparently bases this conclusion on the phrase "except when compliance with § 23.672 is shown."

Proposal 20. The FAA proposed to clarify the requirements of § 23.201(c) by stating the time that the elevator control must be held against the stop to consider the airplane in a stall condition. The FAA recognizes the use of artificial stall barrier systems, such as a stick pusher, as an acceptable means of defining stall. When the system activates, the airplane is in a stall condition. The FAA received comments on this proposal from the GAMA and the JAA.

The GAMA questions the FAA's justification for the proposed requirement for a two-second delay after the control reaches the aft stop during stall determination.

The wording proposed by the FAA would replace the current definition, which reads, "or until the control reaches the stop." Several airplanes have been tested where the elevator has been pulled back to achieve the required speed reduction, but a nose pitch down motion and stall did not occur. Instead, the speed reduction continued until the elevator control reached the mechanical stop and the speed reduction simply stopped. In each of these tests, lengthy discussions between the FAA and the manufacturer have occurred on how long the elevator control needs to be held against the stop before this flight condition can be called a stall. This proposed change defines the stall condition. The FAA chose the two-second interval based on conference discussions and testing experience. The FAA adopts this proposal as presented.

The GAMA also suggests that the last line of § 23.201(c) more appropriately belongs in § 23.201(d)(2).

Section 23.201(d)(2) addresses the power application procedure to be used, if required during stall recovery, and is similar to § 23.201(c). The requirements of § 23.201(c) define when the stall evaluation is completed and assure that engine power is not applied too quickly. To clarify the two different statements on the application of power at the completion of the stall, the requirements of § 23.201(c) are adopted as proposed, and § 23.201(d)(2) is revised to use similar wording.

The JAA notes on § 23.201(f) that it is the power loading and not the weight of the airplane that produces the extremely high nose-up attitudes at 75 percent maximum continuous power; therefore, the proposed relaxation for airplanes of over 6,000 pounds should be extended to all weights of airplanes. The JAA believes that the power-on stall problem should be addressed more directly by placing an upper limit of 30 degrees on the pitch attitude.

The FAA does not agree with the recommendation to place an upper limit of 30 degrees on the pitch attitude. An attitude limit would require extensive and costly flight tests to evaluate various airplane configurations and flight attitudes without a corresponding increase in safety.

The FAA agrees with the JAA's position that the relief proposed for airplanes of more than 6,000 pounds should be extended to airplanes of all weights. When these proposals were developed, the FAA was unaware of any airplanes of 6,000 pounds or less that would have engine power-to-weight ratios capable of producing the extremely nose-high stall characteristics experienced in heavier airplanes. Following the development of these proposals, several airplanes of 6,000 pounds or less maximum weight have been developed with similar power-to-weight ratios. There is a need to allow those airplanes to use the same test procedures proposed for airplanes of more than 6,000 pounds. The FAA has re-examined the stall test procedures and notes that airplanes of all weights have been successfully tested at the current 75 percent maximum continuous power requirement. Therefore, there is a need to consider various power-to-weight ratios likely to occur for airplanes of any weight. Accordingly, the final rule language is revised to allow manufacturers to continue testing at 75 percent maximum continuous power for airplanes at any weight. If this test shows undesirable stall characteristics at extremely nose-high attitudes, the testing may be done in accordance with the power and configuration proposed in the notice for airplanes of more than 6,000 pounds. The final rule provides relief for airplanes that encounter extremely nose-high attitudes and undesirable stall characteristics. The FAA revises proposed § 23.201(f)(4) to allow testing airplanes of any weight for the power requirements discussed. The FAA adopts § 23.201 with the changes discussed above.

As stated in the NPRM, 60 degrees of roll in turning flight stalls would permit a roll to go to 90 degrees, which the FAA considers to be hazardous. The FAA adopts the proposal for § 23.203(b)(4) as proposed.

The JAA concurs with the proposed changes to § 23.203 but notes that the two comments offered on § 23.201(f) relating to power apply equally here.

As discussed in the response to comment on § 23.201(f)(4), the FAA disagrees with the recommendation to place an upper limit of 30 degrees on pitch attitude. An attitude limit would require many tests to evaluate various airplane configurations and flight attitudes without a corresponding increase in safety. Since the NPRM did not address a specific pitch limit, the suggested limit is beyond the scope of the notice and would require additional rulemaking. Also, as previously indicated, the FAA agrees with the JAA recommendation that the relief proposed for airplane weights greater than 6,000 pounds should be applied to all airplane weights. The FAA revises § 23.203(c)(4) to read like § 23.201(f)(4).

The JAA also states that to advocate "normal use of flight controls" in the special circumstances of stall recovery is potentially misleading.

The FAA does not agree. The phrase "normal use of flight controls" has been successfully applied in § 23.202(e) for many years without problems. For example, if ailerons remain effective during the stall, then regaining level flight by using them is appropriate. The FAA adopts § 23.203 with the change discussed above.

Proposal 22. The FAA proposed to revise the critical-engine-inoperative stall requirements of § 23.205 to require that critical-engine-inoperative stalls be evaluated with the wing flaps in the climb position.

The comment received, from the JAA, expresses serious reservations about keeping the critical-engine-inoperative stall requirement. The JAA asserts that the real life one-engine-inoperative stall is not represented by limiting power to 75 percent, by maintaining wings level at the stall, and by utilizing a reduced throttle recovery. Conversely, the JAA states that requiring high asymmetric power to be held down to the stall and throughout the recovery would create an unreasonable risk of spinning. The JAA questions whether this requirement can be of significance in ensuring adequate one-engine-inoperative low speed characteristics in service. The JAA observed that the Transport Category Directorate deleted the equivalent part 25 requirement through amendment 25–72.

Since this issue was not addressed in the NPRM, the FAA is not taking any action at this time. The FAA adopts proposed § 23.205 as proposed.

Proposal 23. The FAA proposed to change § 23.207 to require the current stall warning margins to be applicable to straight stalls, as set forth in § 23.201(c). It also proposed requirements for turning flight and accelerated stalls in a new § 23.207(d). The intent is to ensure that an adequate margin above the stalling speed exists in these two stall conditions.

The FAA received comments from the JAA and the GAMA on this proposal. The GAMA states that the upper stall warning margin should apply to power-off stalls only. The GAMA believes the lead-in of proposed § 23.207(c) should be rewritten to read, "For the power-off stall tests required by 23.201(c) . . . ." According to the GAMA, applying § 23.207(c) to the power-on stall conditions of § 23.201(c) would result in very high deck angles for airplanes with high thrust-to-weight ratios. With a stall warning greater than the 10 knot limit, or 15 percent of the stalling speed limit, the commenter feels that the pilot will be alerted sooner and, thus, avoid excessively high deck angles. The GAMA notes that multiengine airplanes at maximum weight, aft c.g., and high power can fly at airspeeds below V_{MC}. If the difference between V_{MC} and the stall speed is greater than 10 knots, or 15 percent of the stall speed, the GAMA believes the airplane could be difficult to recover if the critical engine fails. According to the GAMA, a stall warning greater than 10 knots, or 15 percent of the stall speed, reduces the time the airplane will be below V_{MC} without a stall warning. The GAMA states that an

The JAA concurs with the proposed amendments. However, the JAA is concerned with the FAA's explanation for rejecting Conference Proposal 160 concerning the audibility of a stall warning when wearing headsets. The JAA believes that regulating the use of headsets, regarded as personal instead of airplane equipment, would be difficult. The JAA states that it would be unusual to see an AFM prohibition on the use of certain types of headsets and questions whether such a limitation would be observed. The JAA states it is therefore essential to ensure that all audio warnings remain adequately audible with any standard of headset that is likely to be used in service. The JAA states that the following words are being considered for JAR 23.1431(d): ''If provision is made for the use of headsets, it must be demonstrated that all aural warnings are effective, with all permitted types of such equipment in use under the most adverse conditions.'' The JAA concludes that the FAA apparently does not intend to regulate this subject.

The FAA discussed this issue in the NPRM but did not make a specific proposal. This issue is under consideration for a future rulemaking.

After publishing the NPRM, the FAA recognized that the second sentence of the proposed § 23.207(d) prohibits a stall warning occurrence when a stall is imminent. The intent of the proposal was to preclude nuisance stall warnings. Revised § 23.207(d) clarifies that stall warnings should not occur when utilizing AFM procedures. The FAA adopts § 23.207 with the change discussed above.

Proposal 24. First, the FAA proposed to clarify § 23.233(a) by specifying that the crosswind requirements must be demonstrated. Second, it proposed to revise § 23.233(b) to make the rudder effective at half the touchdown speed. Third, it proposed seaplane directional stability and control requirements to ensure better handling during water operations up to the maximum crosswind velocity of 0.2 V_{SO}.

The FAA received comments on this proposal from the JAA and from a private individual. The JAA believes that it is necessary to establish the maximum crosswind conditions under which safe operation has been demonstrated and to publish this information in the AFM. The JAA suggests that, with the addition of the word ''taxiing,'' the words currently proposed for JAR 23.233(a) are preferable. They are: ''(a) A 90° cross-component of wind velocity, demonstrated to be safe for taxiing, take-off and landing, must be established and must not be less than 0.2 V_{SO}.'' The FAA concurs with this suggestion and revises § 23.233(a) to agree with the JAR wording.

The other commenter states: ''Paragraph 23.233 as proposed is unclear and grossly unrealistic. It is not clear that 23.233(a) applies during landing or takeoff as well as taxiing. Moreover, 0.2 V_{SO} is inadequate for normal operation of small airplanes. That velocity is less than seven knots for airplanes offered currently. Small airplanes are routinely operated in crosswinds several times as great.'' The commenter believes that § 23.233(a) should be revised to read: ''(a) It must be demonstrated that there is no uncontrollable ground or water looping tendency in 90° crosswinds, up to a wind velocity of 0.5 V_{SO}, but not less than 15 knots, at any speed at which the airplane may be expected to be operated on the ground or water during landing or takeoff.'' The commenter also notes that many small airports have single runways that are subject to crosswinds substantially exceeding the demonstrated crosswind components of existing airplanes but that operations proceed regularly in these conditions. The commenter concludes, ''The regulations should agree with the clear public need.''

In response to this commenter, the FAA notes that the change to § 23.233, made in response to the JAA comments, clarifies that § 23.233(a) includes landing, takeoff, and taxiing. Since the FAA did not propose crosswinds above 0.2 V_{SO} in the NPRM, it is inappropriate to apply a more stringent crosswind criterion in the final rule.

The JAA also states that there is no need to address seaplanes separately in a proposed new § 23.233(d), which refers to § 23.233(a). The FAA disagrees. Seaplanes need to be addressed separately. As stated in the NPRM, seaplane step taxi and step turns are conditions that need separate investigation; therefore, § 23.233(d) is adopted as proposed. The FAA adopts § 23.233 with the change discussed above.

roughest surface that may reasonably be expected in normal operation.''

The FAA concurs and changes § 23.235(a) for clarification. The GAMA mentions that § 23.235(a) proposes to cover rough field takeoffs and landings, but the title of the existing rule limits its content to taxi operations. The FAA agrees and has revised the section title.

The GAMA states that the means of compliance is unclear and asks whether takeoffs and landings on rough ground must be demonstrated. The clarification of § 23.235(a) discussed above resolves this issue.

The GAMA also notes that § 23.235(b) proposes inclusion of ''allowable'' sea conditions for floatplanes in the AFM. The GAMA believes that this establishes an inappropriate limitation of little use to a pilot contemplating a landing. At most, the GAMA states, a statement of demonstrated wave height for operations should be included in the AFM. The FAA concurs with the GAMA's view and § 23.235(b) is revised as suggested.

The JAA wants AFM information to appear in subpart G, not subpart B, and suggests transferring the intent of proposed § 23.235(b) to §§ 23.1583 and 23.1585. The FAA concurs and moves the AFM portion of § 23.235(b) to § 23.1585. Sea conditions are not an intended limitation so it is inappropriate to move the AFM portion to § 23.1583. The FAA adopts § 23.235 with the changes discussed above.

Proposal 26. The FAA proposed clarifying in § 23.251 that buffeting must not cause structural damage anywhere in the flight envelope and specifying a single value of design dive/Mach speed, V_D/M_D, rather than the minimum value of design dive speed, V_D, permitted in the structural requirements. Since the only comment from the JAA agrees with the proposed change, the FAA adopts § 23.251 as proposed.

Proposal 27. The FAA proposed to change § 23.253 to expand the trim condition in § 23.253(a) from ''any likely cruise speed'' to ''any likely speed,'' which encompasses the descent trim condition. Since the only comment from the JAA agrees with the proposed change, the FAA adopts § 23.253 as proposed.

Proposal 28. The FAA proposed to revise § 23.305 to clarify the meaning of failure during static ultimate load test.

The one commenter, the JAA, questions why the ''liberal interpretation'' mentioned in the NPRM occurs in applications of part 23 regulations and not in part 25. The FAA addressed this issue in the FAR part 23 Airframe Airworthiness Review, which identified inconsistent definitions of failure during ultimate load testing. Advisory Circular 23–6, which resulted from that meeting, addresses this commenter's concerns. The Transport Airplane Directorate, which is responsible for part 25, is aware of the part 23 regulatory action.

The FAA adopts § 23.305 as proposed.

Proposal 29. The FAA proposed a new requirement to correct structural test results for material correction factors in § 23.307. The FAA received comments on this proposal from the GAMA, the JAA, and from Transport Canada.

The GAMA states that the proposed amendment is impractical and, perhaps, impossible to meet. The GAMA notes that under current regulations a factor of safety of 1.5 times limit load covers variations in material mechanical properties, construction dimensions, and load predictions. Also, the GAMA notes that the 1.5 factor has proven satisfactory for ultimate strength for more than 60 years. The GAMA recommends withdrawing the proposal.

Transport Canada notes difficulties when accounting for material and dimensional variations of the many subcomponents, determining their effect on the strength tests, and justifying a material correction factor of a singular value. Transport Canada proposes a ''practical alternative'' for low budget manufacturers of requiring the test specimen to be of lower strength than production articles.

The GAMA recommends that § 23.321(b) be rewritten to require consideration of compressibility effects above Mach 0.6. The GAMA argues that the effects of compressibility below Mach 0.6 are insignificant on flight loads. The JAA argues that compressibility needs to be taken into account only if significant and that compressibility is unlikely to be significant if the airplane Mach number is less than 0.5.

The FAA has reviewed the NPRM proposal and the comments received. To simplify certification procedures of lower performance airplanes, small compressibility effects may be neglected below a design dive speed of Mach (M_D) 0.40. At Mach numbers above zero, theoretical compressibility effects cause an increase in an airfoil lift curve slope. This increase is proportional to the Prandtl-Glauert factor, $1/\sqrt{(1-M^2)}$, where M is the free stream Mach number. This theory correlates very well with wind tunnel tests of airfoils and wings.

Wind tunnel tests provide low speed airfoil data between Mach 0.2 and 0.4. The experimental data contains the theoretical effects of speed between zero and the test Mach number. Taking 0.30 as an average test Mach number, then, according to theory, the lift curve slope will increase by 4 and 10 percent, respectively, at 0.40 and 0.50 Mach numbers. The FAA considers the latter figure to be a significant increase.

Considering this problem, the FAA reviewed the design dive speeds for some light airplanes certificated under Civil Air Regulation (CAR), part 3. It calculated an M_D somewhat less than 0.4 at 15,000 feet in the standard atmosphere. One of the airplanes examined, a turbocharged version, had a maximum operating altitude of 24,000 feet and an M_D somewhat greater than 0.5.

The FAA has decided that the effects of compressibility must be considered by the applicant. Compressibility threshold significance varies due to wind tunnel data and testing methods, altitudes, and airplane design. For these reasons, the FAA establishes no design dive speed Mach number compliance threshold. The original proposal would have revised paragraph (b) of § 23.321 to provide for the effects of compressibility. Upon reevaluation, the FAA has concluded that it would be clearer to add this requirement in a new paragraph (c). The FAA adopts § 23.321 with the changes discussed above.

Proposal 31. The FAA proposed to correct an error in § 23.361 introduced by amendment 23–26. The error significantly reduced the structural design torque levels required for flight conditions at takeoff power. The intent is that the torque factors of § 23.361(c) apply to all § 23.361(a) conditions.

Since the only comment received, from the JAA, agrees with the proposed change, the FAA adopts § 23.361 as proposed.

Proposal 32. The FAA proposed to change the heading of § 23.369 by eliminating the phrase "Special conditions for" at the beginning of the heading. The content of § 23.369 remains unchanged.

The one commenter, the JAA, agrees with the editorial change and asks whether this is the only part of the structure needing special consideration in reversed airflow conditions. The FAA is not aware of any additional need for special consideration based on 30 years of service history. The FAA adopts § 23.369 as proposed.

Proposal 33. The FAA proposed to include aerodynamic loads in the design of the engine mount with the gyroscopic loads required by § 23.371. The one commenter, the JAA, suggests adding the word "combined" so the introductory statement reads "designed for the combined gyroscopic and aerodynamic loads. . . ." The FAA agrees and revises the introductory statement. The proposed § 23.371 is adopted with the change discussed above.

Proposal 34. The FAA proposed to increase the minimum rudder force, from 130 pounds to 150 pounds, in the last line of the table of § 23.397(b) to make it compatible with the "strength of pilots" limits shown in § 23.143. Since the only comment received, from the JAA, agrees with the proposed change, § 23.397(b) is adopted as proposed.

weights is beyond the scope of the notice. The recommendation is retained for a future rulemaking notice. The FAA adopts § 23.415 as proposed.

Proposal 36. The FAA proposed to clarify when § 23.473(f) requires a ground load energy absorption test. The FAA received one comment on this proposal. The commenter proposed a wording change that would revise § 23.473(f) and would change the meaning of this requirement. Since the FAA considers the commenter's proposed change beyond the scope of the notice, the FAA adopts § 23.473(f) as proposed.

Proposal 37. The FAA proposed to revise § 23.479(c) to add a new requirement for landing gear spring-back loads. Additionally, this proposal allows for loads development based on testing or rational analyses other than that referenced in appendix D. This proposal also restricts the minimum values of the drag component when using the method referenced in appendix D.

Since the only comment received, from the JAA, agrees with the proposed change, § 23.479(c) is adopted as proposed.

Proposal 38. The FAA proposed to clarify the location and combination of loads in § 23.485. Since the only comment received, from the JAA, agrees with the proposed change, the FAA is amending § 23.485, as proposed.

Proposals 39–47. The FAA proposed to amend § 23.521 and to add new §§ 23.523, 23.525, 23.527, 23.529, 23.531, 23.533, 23.535, 23.537, and a new appendix I, to provide a complete new set of water load requirements. Present part 23 refers to Air Force-Navy-Civil (ANC–3) and incorporates by reference the water loads sections of part 25. Since the one comment received, from the JAA, agrees with the proposal, the proposed amendment, new sections and appendix I are adopted as proposed.

Proposal 48. The FAA proposed to add a new § 23.573, applicable to composite structure, which would require the applicant to apply a damage tolerance evaluation. It also proposed optional damage tolerance requirements for metallic structures.

The proposed optional damage tolerance requirements caused confusion, so in this final rule the FAA has referenced this optional provision in new §§ 23.571(c) and 23.572(a)(3). Further, in § 23.573, the FAA added a lead sentence informing the applicant that composite structure must be evaluated using § 23.573. Now, when the applicant reads these three sections, it should be clearer that damage tolerance is mandatory for composite structures and optional for metallic structures.

The FAA received substantive comments on this proposal from the GAMA, the JAA, the CAA-Australia, and Transport Canada. The CAA-Australia's views on fiber reinforced plastics (FRP) are:

1. They exhibit very complex failure mechanisms.

2. Fatigue failures usually show multiple defects throughout the specimen; for metallic structures, a single crack is frequently observed.

3. Four basic damage modes occur. These are matrix cracking, delamination, fiber fracture, and interfacial debonding. These damage modes may occur singly, or in combination, and interact with each other.

Based on these views, the CAA-Australia believes that: (1) primary structure that has undetectable damage must carry design ultimate load; (2) that this structure must also carry design limit loads if the damage is detectable; and (3) when detectable damage occurs, the airplane must be removed from service unless it can be shown that the structure will always carry ultimate load with that damage.

The CAA-Australia believes that FRP structures should be designed to carry the ultimate load when manufacturing or service damage exists that is not immediately obvious. This position is based on the lack of knowledge about actual damage initiation, propagation rates, inspection difficulties, and material that is vulnerable to invisible accidental damage. The CAA-Australia offers the following additional comments on proposed § 23.573:

4. The proposal is interpreted to require analyses, or proof testing, of production bonded joints in metallic structures, regardless of whether they have been evaluated as safe life or damage tolerant.

5. The words ''and/or'' in the introductory text of the proposal should be revised to read ''and'' to clarify that both the wing and pressurized cabin must be evaluated.

6. The primary structure should be inspected even when a ''no growth (zero growth)'' crack exists. Also, visual inspections may be misleading. The intent of part 25, and the proposal for part 23, is to maintain safety by inspection given uncertainties in the design process, and errors in manufacturing, maintenance, and operation.

7. The term ''barely visible damage'' should be avoided. Certain nondestructive inspection (NDI) techniques are believed to ''find'' defects, to ''see'' defects. Considering NDI, ''visible'' is no longer a word associated only with human vision. Also, the commenter notes that, if the unaided eye visual inspection is accepted as a threshold for detecting damage, explicit inspection procedures should be provided. It is not acceptable to use maintenance procedures or the pilot's preflight inspection as the means of accomplishing visual inspection.

The GAMA comments on this proposal:

1. The NPRM heading ''Water Loads'' for § 23.573 is a typographical error.

2. The proposal would add a requirement that makes the damage tolerance evaluation a requirement for composite structure and an option for metallic structure.

3. Many requirements for composite structure are not appropriate for metallic structure.

4. The proposal contains detailed acceptable means of compliance that should be removed and placed in an Advisory Circular.

Based on the above stated positions, the GAMA submitted a proposed complete revision of § 23.573 that would more clearly present the criteria for composite and metallic structure.

The JAA comment states that the proposed provisions of JAR 23 relating to composites are also based on recently issued FAA special conditions and is therefore largely technically harmonized with the proposed new § 23.573. However, the JAA notes several concerns:

1. Unlike previously issued special conditions, the proposal only addressed pressurized cabin structure and omitted critical fuselage structure.

2. The proposal for § 23.573(k) for structures, where damage tolerance methods are shown to be impractical fails to require previously issued special conditions. These special conditions required a residual strength test to ultimate load after completion of the fatigue test. The JAA recommends inserting this provision because the operator would be unaware of any reduction in strength capability.

3. The editorial layout of proposed § 23.573 is potentially misleading as to its applicability to metallic and composite structures.

The FAA reviewed the above comments and, in general, concurs. Special conditions issued earlier for composite airplanes were used as the basis for this proposed new section. Many of these special conditions were prepared and issued before AC 20–107 was issued. Therefore, there was no guidance available for composite structures and it was appropriate for those special conditions to include acceptable means of compliance. The regulations should be limited to minimum airworthiness standards to be met by an applicant for a type certificate and the acceptable means of compliance should be included in advisory circulars. The FAA finds that AC 20–107 contains much of the guidance needed for compliance with the requirement in proposed § 23.573. If there is a need, the FAA will develop and issue additional guidance. Based on the comments, the FAA has carefully reviewed the proposal and has deleted the redundant material and the guidance material from the final rule.

included in the general requirements of the introductory text in the notice. The words ''material variability and environmental conditions'' in § 23.573(j) cover the list of conditions, such as temperature and humidity, that were spelled out in the proposal and that are removed from the final rule. AC 20–107 contains information about this topic.

2. Section 23.573(a)(1) of the final rule contains the text of the first sentence of proposed § 23.573(b). The FAA guidance material in the second sentence of proposed § 23.573(b) is included in AC 20–107.

3. Section 23.573(a)(2) comes from proposed § 23.573(c). Certain explanatory words were removed from this paragraph. Section 23.573(a)(3) is a combination of § 23.573(g) and (h), in the proposal. Section 23.573(g), for pressurized cabins, and § 23.573(h), for other parts of the airplane, contained common testing requirements that have been combined. The structural items, such as the wing, identified in proposed § 23.573(h) appear in final rule § 23.573(a) and are not repeated in § 23.573(a)(3). The special consideration for pressurized cabin structure in proposed § 23.573(g)(1) and (g)(2), is now included in final rule § 23.573(a)(3)(i) and (a)(3)(ii).

4. Section 23.573(a)(4) is the same as § 23.573(d) in the NPRM. Section 23.573(a)(5) is the same as § 23.573(i) in the NPRM. Verifying the strength of bonded joints by non-destructive testing is added to this paragraph to provide a third acceptable means of approval.

5. Section 23.573(a)(6) comes from § 23.573(k) in the NPRM. This paragraph is rewritten for consistency with the other paragraphs in this section.

6. Instead of the composite damage tolerance requirements proposed for metallic structures by § 23.573(a) in the NPRM, the final rule provides these requirements in § 23.573(b).

7. Section 23.573(c) combines the proposed requirements of § 23.573, paragraphs (e) and (1), from the NPRM and makes this a requirement applicable to composite structures. Those inspection requirements also apply to metallic structures subject to the optional damage tolerance provisions of final rule § 23.573(b).

8. Proposed § 23.573(f) is deleted in the final rule. This paragraph described load spectra, load truncation, and types of damage that must be considered in the damage tolerance evaluation. It contained advisory material on testing methods and did not contain any testing requirements. Though this paragraph is removed, the topics identified must be considered and documented in any damage tolerance evaluation.

The FAA adopts § 23.573, with the changes discussed above and includes revisions to §§ 23.571 and 23.572.

Proposal 49. The FAA proposed to revise § 23.613 to place into part 23 the probability basis used for establishing material allowables. The probability basis appears in MIL-HDBK–5 and is duplicated in §§ 23.613 and 23.615.

The FAA received comments on this proposal from the GAMA, the JAA, and Transport Canada. The JAA agrees with the proposals because they significantly harmonize with JAR 23.

The GAMA believes that § 23.613(c) should continue to list the various strength authority documents (MIL-HDBK–5 and others) to make it clear that these references continue to be acceptable. The FAA agrees that these references are still acceptable and concludes that since this material is advisory, it is more appropriate that it be included in an advisory circular.

Transport Canada suggests substitution of the word ''design'' for the word ''strength'' in proposed § 23.613(d) on the ground that a ''design detail may have high static strength but still be a poor design from the point of view of fatigue.'' The FAA agrees and has amended the paragraph accordingly. The proposed § 23.613 is adopted with the changes discussed above.

The JAA states that it is sympathetic to the FAA's proposed revision to § 23.621(c)(1)(ii) but requests the sharing of FAA's experience concerning the adequacy of a factor of 2.0. All available experience was shared in discussions at the Airworthiness Review Conference; in conference proposals 240, 241, and 242; and in the explanation information contained in the NPRM. The FAA adopts proposed § 23.621(c)(1)(ii) as proposed.

The JAA also states that § 23.621(e), regarding non-structural castings, is redundant since present § 23.621(a) already excludes non-structural castings.

After further review, the FAA has concluded that § 23.621(a) refers to "non-structural" fluid systems castings only. Section 23.621(e) includes those fluid systems castings addressed by § 23.621(a), but it is not limited to them. Section 23.621(e) is adopted as proposed and any redundancy between § 23.621, paragraphs (a) and (e), will be addressed by future rulemaking. The FAA adopts § 23.621 with the changes discussed above.

Proposal 52. The FAA proposed to define the dive speed, V_D, to reduce the Mach number from 0.6 to 0.5, and to introduce flutter criteria for damaged structure in § 23.629. The FAA received comments on this proposal from the GAMA and from the JAA.

The GAMA recommends that the proposed changes to § 23.629(d)(1) not be made. This commenter recommends that the Mach cut-off references remain at 0.6 and 260 knots (EAS) and that the reference to altitude be eliminated. The JAA states that since "260 kt EAS at 14,000 feet is MO .5, this has been proposed for JAR 23."

The FAA has determined that the Mach number 0.5 is technically more appropriate (and the JAA agrees) to the 260 knot (EAS) requirement and causes no significant flutter certification problem. After further review, the FAA has decided that the reference to altitude, although technically correct, is irrelevant; therefore, it is removed.

The GAMA proposes that V_D/M_D would be more appropriate than V_D alone. The FAA agrees and changes the proposal accordingly.

The GAMA also asks the FAA to revise § 23.629(g) and (h) to clarify that the phrase "analysis only" is the regulatory requirement.

The FAA disagrees. As proposed, § 23.629(g) and (h) require an analysis and permit certification by testing. An "analysis only" requirement would effectively discourage and prohibit other certification substantiation. The words "by analysis or test" replace the words "by analysis" in paragraphs (g) and (h) By this change, the applicant is required to show that the airplane is free from flutter up to V_D/M_D, but is permitted to use analysis or other means that are appropriate for the design.

Finally, the GAMA proposes that the analytical flutter clearance factor of 1.2 V_D in § 23.629(b) be changed to 1.15 V_D. Changes to § 23.629(b) are outside the scope of this NPRM. The FAA will consider this in future rulemaking projects.

The JAA observes that V_D is not explicitly stated in proposed § 23.629(h) although it is in proposed § 23.629(g). The FAA agrees that both paragraphs should address V_D, and final rule § 23.629(h) is revised accordingly. The FAA adopts § 23.629 with the changes discussed above.

Proposal 53. The FAA proposed to extend the installation requirements in § 23.655, currently applicable only to the tail surfaces, to include all control surfaces.

Since the only comment, received from the JAA, agrees with the proposed change, the FAA adopts § 23.655 as proposed.

Proposal 54. The FAA proposed to add a new § 23.672 that provides criteria for approval of certain stability augmentation devices, and automatic and power-operated systems.

Proposal 55. The FAA proposed to revise § 23.679 by adding provisions for an automatic-disengage control lock system. The proposal would also add requirements for the locks to be installed so they limit operation of the controls and thereby provide the pilot with an unmistakable warning that the controls are locked at the start of the takeoff roll.

The FAA received comments on this proposal from the GAMA, the JAA, and the ALPA. The ALPA strongly supported the proposed change.

The GAMA believes that the proposal would add to the cost and complexity of the control lock system without a commensurate benefit. The GAMA is unaware of any adverse service history resulting from installed control locks and believes that the current rule provides an adequate level of safety. In support of this position, the GAMA includes an estimated cost of $250,000 to develop a fully automatic gust lock system for a type certificated airplane model.

To evaluate and resolve the GAMA comments, the FAA has reviewed the original conference proposals, numbers 252, 253, and 254. It has also reviewed the record of the public meeting. In response to the GAMA comment concerning any adverse service history, this review shows that the original conference proposals were submitted because accidents were occurring because of control locks that remained installed during takeoff. The economic analysis of the proposals in the notice also identified this accident service history and showed severe airplane damage, pilot injuries, and possible fatalities.

The FAA is aware that an automatically released control lock system would be costly. The proposal did not mandate the installation of an automatic system, but would add an optional provision that would show the acceptance of such systems.

The JAA stated its assumption that the proposed requirement would not be applicable to external locks. Based on the comments received, the FAA has re-examined the proposal. Since the proposal would have eliminated the current § 23.679(a), external systems that use the red warning ribbons as a means of warning the pilot that the locks are in place would no longer be acceptable. The FAA has determined that there is a need to retain the provision of current § 23.679(a), so that presently used locks and their warning systems remain acceptable. The added provision of § 23.679(a)(2) will make it clear that systems that automatically disengage the locks are also acceptable but not mandatory.

The proposal to limit the operation of the airplane when the locks are engaged is being restated since control locks and their warnings can be overlooked and automatic disengage systems will fail. The FAA believes an additional safeguard is required. By requiring a system that will ensure that airplane operation is limited, the pilot will receive a pre-takeoff warning and thus a hazardous takeoff will not be attempted.

In summary, the FAA has considered the comments and has revised the proposed rule language by retaining the current provisions of § 23.679(a) and § 23.679(a)(1), and by adding the provision for accepting automatically disengaged locking systems as an option. The language in proposed § 23.679(a)(2) to require the control surfaces to be locked so the pilot receives an unmistakable warning at the start of the takeoff if the locks have not been removed is retained as § 23.679(b). The unmistakable warning required by this paragraph may be a tactile warning that the pilot receives by the feel of the controls. Finally, proposed § 23.679(b) is retained as paragraph (c).

The FAA has determined that these changes are not substantive and will clarify this requirement by providing relief from the provisions identified by the commenters. The FAA adopts § 23.679 with the changes discussed above.

Proposal 56. The FAA proposed to revise § 23.729, paragraphs (f)(1) and (f)(2), by changing the power and flap settings necessary to warn the pilot that the landing gear is not fully extended and locked.

The FAA received two comments on this proposal from the JAA and the ALPA. The ALPA strongly supported the proposed change.

them. Proposed § 23.729(f)(2) would have required a landing gear warning when the flaps are extended beyond the approach setting. That change would eliminate the nuisance warnings occurring when flaps are set ''to'' the approach flap position. Subsequent to the issuance of the notice it has come to FAA attention that many airplanes have more than one approach flap setting and that the proposal would be unclear as to which approach flap setting should be used as the threshold for the gear warning. Also, if the lower approach flap setting is used, nuisance warnings could occur because that setting is also frequently used for takeoff flaps. To clarify this requirement, the proposal has been revised to require the gear warning when the flaps are extended beyond the maximum approach flap position. The FAA adopts § 23.729 with the changes discussed above.

Proposal 57. The FAA proposed to remove § 23.731(a), which contains a requirement that each main and nose wheel must be approved. Since there is a basic requirement to approve the complete airplane, including all components, parts, and appliances, § 23.731(a) is unnecessary. No comments were received on this proposal, and the FAA adopts § 23.731, as proposed.

Proposal 58. The FAA proposed to remove the current § 23.733 reference to the tire rating assigned by the Tire and Rim Association. This would be accomplished by:

1. Stating that tire ratings must be approved.

2. Requiring that static and dynamic ratings be established.

3. Defining the conditions where those ratings are to be used.

The FAA received comments on this proposal from the GAMA and the JAA. The JAA asks the FAA to explain the undiscussed change in the drag reaction from 0.21W to 0.31W.

At least one publication of part 23 regulations contains a typing error that gave this reaction as 0.21W. The FAA has reviewed the history of this requirement and verified that the value of 0.31W that is in § 23.733(a)(2), as published in the Code of Federal Regulations, is correct.

The GAMA questions the removal of the reference to the Tire and Rim Association and recommends its retention. In the NPRM, the FAA identifies the existence of other organizations whose appropriate rating also would be considered. The FAA adopts § 23.733 as proposed.

Proposal 59. The FAA proposed to remove the first sentence of § 23.737 that states that each ski must be approved. Since the only commenter, the JAA, agrees with the proposed change, the FAA adopts § 23.737 as proposed.

Proposal 60. The FAA proposed to revise § 23.751 to clarify the buoyancy requirements for the main floats of seaplanes. Since the only commenter, the JAA, agrees with the proposed change, the FAA adopts § 23.751 as proposed.

Proposal 61. The FAA proposed to remove the words ''must be approved'' from the main float design requirements in § 23.753. Since the only commenter, the JAA, agrees with the proposed change, the FAA adopts § 23.753 without change.

Proposal 62. The FAA proposed to add wording to the hull requirements for seaplanes in § 23.755 to clarify that airplanes must be kept afloat without capsizing. Since the only commenter, the JAA, agrees with the proposed change, the FAA adopts § 23.755(a), introductory text, as proposed.

Proposal 63. The FAA proposed to revise the § 23.773 requirements for the pilot compartment view to address the environment expected in all the operations requested for certification.

The JAA states that it will consider this change for JAR 23 but that it proposes to retain present paragraph (b) relating to night flight tests. The GAMA contends that the words ''must be shown in all operations for which certification is requested,'' could be interpreted to mean that the same view must be provided for all operations.

the GAMA and the JAA.

The JAA does not find the proposal for § 23.775(f) acceptable for inclusion into JAR 23. The JAA does not provide any suggested changes.

In reviewing this comment, the FAA notes that the proposal for § 23.773 identifies the need for a clear and undistorted view for these same four operations and the ability to "perform any maneuver within the operating limitations of the airplane." If the airplane is approved for operation in known or forecast icing conditions, the requirements of § 23.773 will be applicable. Section 23.775(f) should be the same as § 23.773. Accordingly, § 23.775(f) is revised to be the same as § 23.773.

The JAA also believes that transparency heating systems, covered by proposed § 23.775(g), should be certificated under the principles of § 23.1309. The FAA notes that § 23.1309 applies to all systems, as defined by § 23.1309(f), and would apply to transparency heating systems. The provisions of the proposal for § 23.775(g) identify specific hazards that could occur. These specific hazards would have catastrophic consequences and must be avoided through the use of appropriate designs.

The other commenter, GAMA, notes that its comments on proposal 63 also apply to this proposal to clarify criteria for determining cleared windshield areas. The FAA addresses the concern about the amount of cleared windshield under proposal 63. The response is also applicable to the cleared area needed for the operations identified in this proposal. The FAA adopts § 23.775 with the change discussed above.

Proposal 65. The FAA proposed that § 23.851 be revised to require a hand fire extinguisher to be located in the pilot's compartment of all airplane categories. This proposal would also add minimum standards for hand held fire extinguishers. The FAA received comments on this proposal from the JAA and the GAMA.

One commenter, JAA, believes the requirement in current § 23.851, paragraphs (a) and (b), is more appropriate for the operating rules.

The FAA does not agree with this commenter's position. It is incorrect to allow an airplane to be certificated and not include the equipment required for the airplane to be placed in operation. When this occurs, the new owner/operator must then install the required equipment. Such an installation would not only need to meet the operating rules but also would need to meet the requirements of §§ 23.851 and 23.561(b)(3). Because the operator may not have the structural design data for the airplane, finding a suitable location to install a fire extinguisher meeting the load factors of § 23.561 could be difficult. Such installations are more easily accomplished by the airframe manufacturer. The requirements of current § 23.851(a) and (b) will be retained.

The JAA also notes that proposed § 23.851(c)(2) does not ban extinguishers that use toxic agents. The JAA believes that such agents should be banned. The FAA does not agree with this position. The first consideration in evaluating the use of a hand fire extinguisher is its effectiveness in putting out any in-flight fire. If the best agent for the type of fire that may occur causes toxic gas, the concentration of that gas that would result from a completely discharged extinguisher and its hazard to the occupants must be evaluated. If the concentration would be hazardous, it may still be possible to use the extinguisher if the gas can be vented from the area in a short time, and if there would be no adverse affect upon the occupants. To ban such fire extinguishers could lower the level of safety of the airplane by reducing the chance that in-flight fires can be extinguished. The FAA plans no action to ban the use of such fire extinguishing agents at this time.

The other commenter, GAMA, believes the proposal for § 23.851(a), requiring a hand fire extinguisher to be located conveniently in the pilot's compartment, is too restrictive. The GAMA points out that the pilot's compartment is usually small, therefore, it is frequently difficult to find suitable space for a fire extinguisher. The GAMA recommends revising 23.851(a) to read, "There must be at least one hand fire extinguisher located within easy access of the pilot while seated."

guidance.

The FAA observes that § 91.513(c)(3) requires at least one hand fire extinguisher located in the passenger compartment of each airplane accommodating more than six passengers. Accordingly, this operating rule and the NPRM are not compatible. If the requirements in the notice were adopted as proposed, normal category airplanes that accommodate more than six passengers could be certificated without a passenger compartment fire extinguisher. Then, operators of those airplanes would be required to have an extinguisher installed.

The FAA discussed, in the NPRM, the burden that would fall on the operator if that operator needed to install a new fire extinguisher that also must meet other current airworthiness requirements. For consistency with § 91.513(c)(3), the final rule § 23.851 has been revised to require a fire extinguisher in the cabin of airplanes that accommodate more than six passengers. The FAA adopts § 23.851 with the changes discussed above.

Proposal 66. The FAA proposed to clarify the existing requirement of § 23. 865 by excluding those portions of the engine mount certificated with the engine and by addressing the allowable damage expected on engine isolators. Since the only commenter, JAA, agrees with this proposal, the FAA adopts § 23.865 as proposed.

Proposal 67. The FAA proposed a change to § 23.1507 to establish an operating maneuvering speed (V_O) different from the design maneuvering speed (V_A) established by § 23.335(c). V_O is the maximum speed where, at any given weight, the pilot may apply full control excursion without exceeding the design limit load factor.

The one commenter, the JAA, believes that this new concept of V_O needs further discussion. The JAA also notes that, while proposed § 23.1507(a), establishing an operating limitation, is correctly located, § 23.1507(b), which defines V_O, should be moved to become § 23.335(d) while retaining the existing definition of V_A, design maneuvering speed, at § 23.335(c).

The FAA disagrees with moving the V_O definition to § 23.335, since it would put an operational definition in the design section of part 23. The V_O definition in § 23.1507 is consistent with the requirements of §§ 23.1505 and 23.1511, namely, that the relationships between "operating" speeds and "design" speeds are established. The comment has caused the FAA to re-examine and reword proposed § 23.1507. The revised wording deletes the definitions of computed stall speed (V_S) and the limit maneuvering load factor (n) and utilizes those already contained in § 23.335. The final rule section heading includes the word "operating" to maintain a distinction from the design maneuvering speed of § 23.335. The FAA adopts § 23.1507 with the change discussed above.

Proposal 68. The FAA proposed to add a new § 23.1516 that establishes an intentional one-engine-inoperative speed for pilot training.

The one commenter, the JAA, refers to its comments on proposed § 23.149. The FAA agrees that V_{SSE} should not be established as a limitation; therefore, it deletes the proposed § 23.1516.

Proposal 69. The FAA proposed to change § 23.1521 to ensure that powerplant limitations established for airplane certification do not exceed those established during the certification of the engine or the propeller, and are in accord with limitations used in determining compliance with this part.

The one commenter on this proposal, JAA, notes that examples from FAA experience would be useful in the preparation of interpretations. The FAA's principal experience involves derated engines and some turbopropeller engine installations that have a higher maximum power at cruise than at takeoff. The FAA adopts § 23.1521 as proposed.

Proposal 70. The FAA proposed to add a new § 23.1522 that specifies auxiliary power unit (APU) limitations in the operating limitation section of the AFM.

rather than requirements. The JAA believes that what is needed is a requirement that establishes the kinds of operations authorized and the resulting airplane operational limitations. The JAA suggests a slightly modified version of proposed JAR 23.1525, as follows: "The kinds of operation authorised (such as VFR, IFR, day or night) and the meteorological conditions (such as icing) and the category in which the aeroplane is eligible for certification, appropriate to the installed equipment, must be established." The JAA believes that the requirement to furnish this information in the AFM belongs in § 23.1583(h) and that a cross reference, as proposed in § 23.1525, is unnecessary.

The FAA concurs with the JAA's comment and the final rule language is changed to closely follow the JAA's suggested version. The FAA adopts § 23.1525 with the change discussed above.

Proposal 72. The FAA proposed to change § 23.1527 to clarify that the maximum operating altitude allowed for any part 23 airplane must be established based on those limitations determined by flight, structural, powerplant, functional, or equipment characteristics.

The one commenter, JAA, suggests reversing the order of § 23.1527(a) and (b) for clarity. The FAA concurs and adopts § 23.1527 with this change.

Proposal 73. The FAA proposed to change § 23.1545 by deleting current paragraph § 23.1545(b)(6) which requires a red radial mark on the airspeed indicator. This mark identifies the minimum control speed with the critical engine inoperative, V_{MC}, on multiengine airplanes.

The one commenter on this proposal, JAA, states that the red radial line on the airspeed indicator at V_{MC} offers useful guidance to the pilot for this class of airplane and should be retained.

For the reasons given by the JAA, the FAA agrees that the red radial should be retained. The proposed amendment to § 23.1545 is withdrawn.

Proposal 74. The FAA proposed to change § 23.1549 to expand the current powerplant instrument requirements to include auxiliary power units (APU).

The one comment from JAA on this proposed change refers to the JAA's comments on proposed changes to § 23.1522 in which the JAA opposed referencing APU in the absence of requirements addressing APU in subpart C.

As previously stated, since the Small Airplane Airworthiness Review Program Amendment No. 3, Amendment 23–43 (58 FR 18958, April 9, 1993) addresses APU, § 23.1549 is adopted as proposed.

Proposal 75. The FAA proposed to change § 23.1557 to clarify the marking requirements for filler openings and to require a marking for the coolant filler opening similar to the requirements for fuel and oil. The FAA also proposed deleting § 23.1557(f) because the AFM and fuel quantity indicator provide this information to the pilot.

The one commenter, JAA, concurs with the proposed changes, except that the JAA believes that § 23.1557(c)(2), which contains marking requirements for oil filter openings, should end with the words "and the permissible oil designations." While the FAA agrees, after further review, the FAA has determined that, as with fuel filler marking, the oil filler marking should permit reference to the AFM as an alternative. The proposed § 23.1557 is adopted with the change discussed above.

Proposal 76. The FAA proposed to change § 23.1563(a) by substituting V_{SO} for V_A in conjunction with the change to § 23.1507.

The one commenter, JAA, states that V_{SO} should be further considered later, in the light of discussions on proposed § 23.1507. The concept of V_{SO} was discussed under proposal 67 relating to § 23.1507, and for the reasons stated there the FAA adopts § 23.1563(a) as proposed.

Proposal 77. The FAA proposed to change § 23.1581(f) to establish a new requirement for providing a means to record updates to the AFM.

The FAA proposed an introductory sentence to § 23.1583. During the type certification process, there are limitations required other than those specified by this section. The FAA proposed to expand § 23.1583(h) to identify the kinds of operation that were type certificated, such as icing. Also, the section was proposed to be revised to identify installed equipment that must be operable for aircraft operation in icing conditions. The NPRM also proposed a new § 23.1583(m). Although § 23.23, Load distribution limits, generally covers it, the effects of an asymmetric fuel load are not emphasized. The effects of lateral fuel imbalance are not usually addressed although the lateral center of gravity limits must be furnished in the AFM.

The FAA received comments on this proposal from the GAMA and the JAA. The commenters on the proposal for § 23.149, which would establish a safe, intentional, one-engine-inoperative speed, V_{SSE}, as a limitation in § 23.1583, oppose the inclusion of V_{SSE} in § 23.1583(a)(2). In response to these comments, the FAA agrees that this speed should not be established as a limitation and V_{SSE} is removed from § 23.1583(a)(2). Revisions to §§ 23.149 and 23.1585 require manufacturers to determine a safe one-engine-inoperative speed and provide this information in the AFM.

The JAA also notes that the words "of each airplane" in the introductory statement are not necessary and should be removed. The FAA concurs. While reviewing comments on § 23.1583(a)(2), the FAA noted that since V_A is removed as an airspeed limitation in § 23.1507, V_A should also be removed from § 23.1583(a)(2).

The JAA states that, having established the kinds of operation authorized under § 23.1525 (VFR, IFR, day, night, and others), § 23.1583(h) is merely to require that this information be made available in the AFM. The JAA suggests words based on JAR 23.1583, as follows:

"The Aeroplane Flight Manual must contain:

* * * * *

(h) Kinds of operation. A list of the kinds of operation to which the aeroplane is limited under 23.1525 for which approval has been given." If the FAA retains proposed § 23.1583 as proposed, the JAA suggests replacing "is requested" with "has been given." The JAA also notes the need to identify the required operational status of installed equipment, where this may affect operation limitations, will be proposed as an extension to JAR 23.1583(i).

The GAMA states that "The last sentence of proposed § 23.1583(h) is confusing and subject to multiple interpretations. Certain equipment, such as deicing equipment, might be appropriately included in a listing that affects operating limitations (flight into known icing in this example) but, reference to the kinds of operation for which approval is requested may lead to confusion and continue the argument that has been going on for more than ten years with respect to minimum equipment lists versus what is required (required equipment lists) for a particular operation. Most operators of part 23 airplanes, including operators of single-engine personal use airplane, have traditionally equipped their airplanes according to their personal operational requirements and preferences. This will become even more true in the near future as alternate sole source navigational systems are approved. The proposed wording of the last sentence of paragraph 23.1583(h) appears to require that a detailed minimum equipment list be included in the limitations section of the AFM. This in turn requires a supplemental type certificate for any variation from the manufacturer's standard installed equipment list. Such a list might well be appropriate as a 'required' equipment list for various kinds of operations and may be interpreted to provide operational authority for such operations. However, it is more likely that it will perpetuate the confusion of what must be operative and what may be inoperative during a particular flight. This item needs further review."

The FAA agrees that a reference in § 23.1583(h) to the kinds of operation within § 23.1525 is appropriate instead of repeating examples of kinds of operations. This change and the other change suggested by the JAA are made in the final § 23.1583(h).

multi-engine airplanes; therefore, the FAA proposed to eliminate the reference to commuter category and to turbine engines.

The FAA received comments on this proposal from the JAA and the CAA-UK. The CAA-UK comment addresses conference proposals that the FAA rejected and, as previously stated, this preamble does not address comments on rejected conference proposals. The JAA notes that the proposed changes align closely with JAR 23.

The JAA believes that GAMA Specification No. 1 is acceptable and fears that certain of the proposed changes may conflict with it. The FAA recognizes that GAMA Specification No. 1 may need to be revised.

Also, the JAA states that it is "unclear from what the operating procedures 'must be . . . segregated'" in the AFM.

With the addition of abnormal procedures to normal and emergency procedures covered under the present rule, the FAA's intent is that the AFM be organized so that abnormal procedures are clearly separated from normal procedures, etc.

The JAA notes that procedures for maintaining and recovering control following engine failure above or below V_{MC} are still required in spite of the NPRM explanation that these are within the scope of basic airmanship. The FAA concurs with the JAA that the explanation in the NPRM shows that recovering of control above and below V_{MC} is within the scope of basic airmanship. These procedures were inadvertently left in the text of the proposed rule as § 23.1585(c)(5); therefore, proposed paragraph (c)(5) is omitted from the final rule.

The JAA states: "In spite of the explanation, FAR 23.1585(d) through (g) appear to remain unchanged although (f), not required for JAR 23, requires for all aeroplanes that a restart envelope must be established. In § 23.1585, however, the operating procedures for restarting of the engine(s) must be furnished for multi-engined aeroplanes only. This inconsistency will lead to confusion."

The JAA comment on § 23.1585(d) through (g) indicates that the text of the NPRM explanation may have been misunderstood. The NPRM explanation noted that non-flight items were considered for the NPRM but not addressed as the NPRM was aimed at flight items. Thus, the FAA did not intend to change § 23.1585(d) through (g).

The FAA does not understand the JAA's reference to § 23.1585(f) with respect to an engine restart envelope for all airplanes, since § 23.1585(f) concerns unusable fuel and indicator marking. Nor does the FAA understand the inconsistency suggested by the JAA since the proposed restart procedures are in paragraph (c) which only applies to multiengine airplanes.

In response to comments on proposed § 23.235, as discussed under that section, the FAA is amending § 23.1585(a) to add a requirement for seaplane handling procedures and demonstrated wave height.

Also as discussed in proposal 12, the FAA decided that V_{SSE} should not be a limitation; therefore, a new § 23.1585(c)(6) is added to require that V_{SSE} be furnished to the pilot in the AFM. The FAA adopts § 23.1585 with the changes discussed above.

Proposal 80. The FAA proposed to reorganize and simplify § 23.1587, which specifies the performance information that must be provided in the AFM.

The one commenter, JAA, states that while the proposed changes move considerably towards the proposed text of JAR 23.1587, the JAA has already decided that "the calculated approximate effect" on performance of altitude and temperature is unacceptable.

The JAA states that the maximum temperature at which compliance with the cooling requirements has been shown is wrongly located in the AFM and that it should appear as a limitation in § 23.1521(e), as in proposed JAR 23. Unlike proposed JAR 23.1587, the JAA notes that there is no proposal to

Proposal 82. The FAA proposed to amend appendix D by adding a new paragraph (c), which supports a new requirement in § 23.479(c) concerning dynamic spring-back of the landing gear.

Since the only comment received, from the JAA, agrees with the proposed change, appendix D is adopted as proposed.

Proposal 83. The FAA proposed to add a new appendix H that supports amended § 23.521.

Since the only comment received, from the JAA, agrees with the proposed change, proposed appendix H is adopted as appendix I.

Turbojet Engines

While not proposing any rule change in the NPRM, the FAA requested and received comments about changing part 23 to allow the use of turbojet engines on commuter category airplanes. Comments were received from the ALPA and from the JAA. The ALPA opposes the use of turbojet engines and believes that the certification of turbojet airplanes should remain under part 25 requirements.

The JAA states that since basic FAR/JAR 23 includes turbojets, "there is no fundamental reason for excluding them from commuter category" airplanes. The JAA believes that turbojets provide enhanced reliability compared to reciprocating engines. The JAA also believes that turbojet engines provide better airplane handling characteristics, with one engine inoperative, than any propeller driven airplane (reciprocating or turbine engine powered). The JAA recognizes that part 23 is intended to provide a simplified airworthiness code appropriate to simple airplane designs. The JAA recognizes that the use of turbojet engines has the potential to convey a performance capability involving design complexities not envisioned in formulating FAR 23. The JAA states that it is not opposed to the use of turbojet engines on airplanes certificated to commuter category requirements, subject to a review of requirements related to a higher performance capability (speed and altitude).

Performance Limitations Based on Weight, Altitude and Temperature (WAT)

While not proposing any rule change in the NPRM, the FAA requested comment on the need for WAT criteria, as information or as a limitation on piston-powered twin-engine part 23 airplanes. It also requested comments about WAT criteria on turbine-powered twin-engine part 23 airplanes, specifically during takeoff and landing. The FAA received comments from the JAA, the GAMA, and the ALPA. The ALPA supports the requirement that WAT information be furnished during the certification process. The ALPA cites the variety of operational uses, including scheduled air carrier and regional airline service, and the need for "one level" of safety as justification. The GAMA "believes that WAT information is useful but certainly not the only way to present operating data for any airplane" and that making WAT criteria an airplane or operating limitation for part 23 airplanes is "an unnecessary and unjustified expansion or redirection of operating criteria." The JAA generally supports the use of WAT criteria for part 23 airplane certifications. The JAA believes that the chance of a single-engine failure on any airplane is high. Also, the JAA warns that safety considerations include airplane occupants and personnel on the ground. According to the JAA, transport category airplanes do this by limiting the operation of the airplane. Beyond the point where takeoff can be rejected, one-engine-inoperative climb must guarantee obstacle clearance. The JAA recognizes the need for generally similar requirements for commuter category airplanes.

The JAA believes that a continued flight capability would preclude the operation of single-engine airplanes. Also, the JAA believes that airplane size and stall speed provide characteristics that permit safe landings.

The JAA points out that between the two extremes within present part 23 (from single-engine airplanes to commuter category airplanes) lie the light twin-engine reciprocating and turbine engine airplanes, ranging from four to nine seats and 4,000 to 12,500 pounds. The JAA notes that, for these types of airplanes, and, commonly, loss of directional control that results in a stall/spin accident.

The JAA advocates certification and operations criteria for multiengine airplanes that blend the performance requirements for a single-engine airplane and a transport category airplane. The JAA believes that the requirements accept a limited period for risk just before and just after liftoff where engine failure may not be fully accounted for. The JAA believes that the application of WAT limits clearly accounts for actual conditions, although the climb gradient requirements are lower than those of FAR/JAR 25.

The JAA recommends using compensating operational criteria, like transport category airplanes use, for the lower performance commuter category airplanes. Cockpit visibility and a reasonable maximum speed provide adequate compensation for takeoff so the pilot can see and avoid obstacles as the airplane returns for landing. The JAA does not propose a distinction between reciprocating and turbine engines. Where applicable, the WAT criteria should be imposed, in the JAA's opinion, as limitations through the Airplane Flight Manual (AFM).

The JAA does not believe that such proposals would involve costs disproportionate to the benefits. The JAA suggests that the comment from the airworthiness conference, that such criteria would "eliminate the certification of an entire class of airplanes," is an exaggeration. The proposals are achievable, in the JAA's view, by typical modern light twin-engine airplanes with realistic payloads, particularly the more significant executive/air taxi airplanes. It is the JAA's opinion that adopting this concept would instill a greater awareness of performance consideration in pilots from an early stage of their training.

The JAA also believes that the climb and handling qualities requirements of present §§ 23.65 and 23.67 are illogical and unreasonable. The JAA recommends using WAT criteria, so it applies equally to all airplane operations, because it offers improved airplane capability.

The JAA points out that the manufacturers of "WAT type" airplanes routinely determine performance under a wide range of conditions. The JAA also notes that flight manuals produced to the widely accepted General Aviation Manufacturers Association (GAMA) specification already contain performance data beyond the minimum requirements of part 23. Additional testing or scheduled data create no additional costs in the JAA's opinion. The JAA notes that present draft JAR 23 applies WAT limits only to piston-engine airplanes above 6,000 pounds and turbine-engine airplanes and that it has been proposed to the JAR Operations Group that WAT limits be applied to all JAR 23 airplanes in commercial operation.

Regulatory Evaluation Summary

This section summarizes the full regulatory evaluation prepared by the FAA that provides detailed estimates of the economic consequences of this regulatory action. This summary and the full evaluation quantify, to the extent practicable, estimates of the costs and benefits to the private sector, consumers, and Federal, State, and local governments.

Executive Order 12291, dated February 17, 1981, directs Federal agencies to promulgate new regulations or to modify existing regulations only if potential benefits to society outweigh potential costs for each regulatory change. The order also requires the preparation of a Regulatory Impact Analysis of all major rules except those responding to emergency situations or other narrowly-defined exigencies. A major rule is one that is likely to have an annual impact on the economy of $100 million or more, to have a major increase in consumer costs, or to have a significant adverse effect on competition.

The FAA has determined that this rule is not major as defined in the Executive Order. This section contains a summary of the regulatory evaluation, a regulatory flexibility determination as required by the 1980 Regulatory Flexibility Act, and an international trade impact assessment. The complete regulatory evaluation, which contains more detailed economic information than this summary provides, is available in the docket.

that a fire extinguisher and a suitable bracket cost $40.

The FAA assumes that an average of five airplanes will be certified under part 23 each year during the period of analysis from 1993–2012. Based on discussions with industry, the FAA also assumes that, during the first year following certification, 60 airplanes will be produced per certification. In the second, third, and fourth years following certification, 120 airplanes per year are assumed to be produced. In the fifth and subsequent years, 100 airplanes per year are assumed to be produced. Based on this assumption, the costs of the rule over the 20-year period of analysis total $3.7 million ($1.5 million discounted) or about $48 per airplane produced.

Benefits

The benefits of the rule are two-fold. First, the rule is expected to enhance safety. An examination of accidents that might have been prevented by this rule include those involving control locks that were not removed prior to flight (seven accidents over a five-year period with five fatalities, three airplanes destroyed, and four substantially damaged) and multiengine stall/spin accidents (four accidents over eight years, resulting in nine fatalities and all airplanes destroyed). Had those accidents been avoided by the rule, the benefits would be $5.4 million per year.

Other safety benefits will be realized from the rule. The requirement to demonstrate 1.5g pitch maneuver capability will ensure that a pilot can make 30-degree banked turns and slow down from potential overspeed conditions without encountering low-speed buffeting. Determination of spin-up and spring-back loads will ensure that landing gear fore and aft drag loads, which affect both landing gear and wing strength, will be considered in the design of new part 23 airplanes. The requirement that airplanes be free from flutter will ensure that this dangerous phenomenon does not occur, even after fatigue failure. The rule also requires that additional information about procedures, speeds, and configurations for a glide following an engine failure for single-engine airplanes and procedures for restarting engines in flight for multiengine airplanes be included in the airplane flight manual. This information can lessen the consequences of emergency landings after engine failures. Although the FAA has not quantified the benefits of these requirements, the benefits exceed the generally minor costs.

There were 108 recorded accidents that occurred from January 1989 through April 1991 in which there was fire after impact. Although the number of fatalities and injuries in these accidents that could have been avoided cannot be determined, it is likely that the presence of a fire extinguisher could have mitigated the consequences in at least some of these fires.

Less than $194,000 in average annual accident losses needs to be averted annually to render this rule cost-beneficial. For those control system lock and multiengine stall/spin accidents that could have been prevented or mitigated by the provisions of this rule, the annual losses averaged $5.4 million. This exceeds the $194,000 threshold value, thus, the rule is cost beneficial. In addition, the avoidance of fatalities because of the presence of fire extinguishers in affected airplanes will further increase the benefits. Finally, other requirements, such as those discussed above, will provide additional safety benefits.

Another valuable additional benefit of this rule is that it comports to a large extent with international requirements, particularly the Joint Aviation Requirements (JAR) of the Joint Aviation Authorities (JAA). The creation of common international standards, or harmonization, will benefit manufacturers in the U.S. and those in the countries of the JAA.

The rule modifies certain testing requirements and allows optional evaluations and analysis. This may result in cost savings. However, the FAA does not have sufficient information to quantify such savings.

Regulatory Flexibility Determination

The Regulatory Flexibility Act of 1980 (RFA) requires Federal agencies to review rules that may have a "significant economic impact on a substantial number of small entities." FAA Order 2100.14A,

International Trade Impact Assessment

The rule will have little or no impact on international trade. Both foreign and domestic manufacturers seeking type certification in the United States will be required to comply with the rule. The Joint Aviation Authorities (JAA) is including many of the sections in this rule to harmonize with U.S. aviation regulations. It is expected that other countries will also adopt these requirements.

Federalism Implications

The regulations herein will not have substantial direct effects on the States, on the relationship between the national government and the States, or on the distribution of power and responsibilities among the various levels of government. Therefore, in accordance with Executive Order 12612, it is determined that this regulation will not have sufficient federalism implications to warrant the preparation of a Federalism Assessment.

Conclusion

The FAA is revising the airworthiness standards for normal, utility, acrobatic, and commuter category airplanes as a result of comments received in reply to the Small Airplane Airworthiness Review Program Notice No. 4 dated June 28, 1990. The notice, which addresses airframe and flight items, was published as a result of recommendations discussed at the Small Airplane Airworthiness Review Conference held on October 22–26, 1984 in St. Louis, Missouri. Originally, the proposals reflected updated safety standards and advancements in technology while reducing the regulatory burden for some requirements and maintaining an acceptable level of safety. Harmonization with the European Joint Aviation Authorities Joint Airworthiness Requirements became a dominant factor at the close of the extended Notice of Proposed Rulemaking comment period, December 14, 1990. Considerable effort was invested to harmonize these airworthiness standards because aircraft industry estimates indicate reduced overall certification costs. These airworthiness standards will continue to provide adequate levels of safety for small airplanes used in both private and commercial operations.

For the reasons discussed in the preamble, and based on the findings in the Regulatory Flexibility Determination and the International Trade Impact Analysis, the FAA has determined that this regulation is not major under Executive Order 12291. In addition, the FAA certifies that this regulation will not have a significant economic impact, positive or negative, on a substantial number of small entities under the criteria of the Regulatory Flexibility Act. This regulation is considered significant under DOT Regulatory Policies and Procedures (44 FR 11034; February 26, 1979). A regulatory evaluation of the regulation, including a Regulatory Flexibility Determination and International Trade Impact Analysis, has been placed in the docket. A copy may be obtained by contacting the person identified under "FOR FURTHER INFORMATION CONTACT."

The Amendment

Accordingly, the Federal Aviation Administration amends 14 CFR part 23 of the Federal Aviation Regulations effective September 7, 1993.

The authority citation for part 23 continues to read as follows:

Authority: 49 U.S.C. 1344, 1354(a), 1355, 1421, 1423, 1425, 1428, 1429, and 1430; 49 U.S.C. 106(g).

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(1) By tests upon an airplane of the type for which certification is requested, or by calculations based on, and equal in accuracy to, the results of testing; and

(2) By systematic investigation of each probable combination of weight and center of gravity, if compliance cannot be reasonably inferred upon combinations investigated.

(b) The following general tolerances are allowed during flight testing. However, greater tolerances may be allowed in particular tests:

Item	Tolerance
Weight	+5%, –10%.
Critical items affected by weight	+5%, –1%.
C.G.	±7% total travel.

§ 23.23 Load distribution limits.

[(a) Ranges of weights and centers of gravity within which the airplane may be safely operated must be established. If a weight and center of gravity combination is allowable only within certain lateral load distribution limits that could be inadvertently exceeded, these limits must be established for the corresponding weight and center of gravity combinations.

(b) The load distribution limits may not exceed any of the following:

(1) The selected limits;

(2) The limits at which the structure is proven; or

(3) The limits at which compliance with each applicable flight requirement of this subpart is shown.]

(Amdt. 23–17, Eff. 2/1/77); [(Amdt. 23–45, Eff. 9/7/93)]

(1) Not more than—

(i) The highest weight selected by the applicant;

(ii) The design maximum weight, which is the highest weight at which compliance with each applicable structural loading condition of this part (other than those complied with at the design landing weight) is shown; or

(iii) The highest weight at which compliance is shown, except for airplanes equipped with standby power rocket engines, in which case it is the highest weight established in accordance with appendix E of this part; or

[(2) Not less than the weight with—

(i) Each seat occupied, assuming a weight of 170 pounds for each occupant for normal and commuter category airplanes, and 190 pounds for utility and acrobatic category airplanes, except that seats other than pilot seats may be placarded for a lesser weight; and

(A) Oil at full capacity, and

(B) At least enough fuel for maximum continuous power operation of at least 30 minutes for day-VFR approved airplanes and at least 45 minutes for night-VFR and IFR approved airplanes; or]

(ii) The required minimum crew, and fuel and oil to full tank capacity.

(b) *Minimum weight.* The minimum weight (the lowest weight at which compliance with each applicable requirement of this part is shown) must be established so that it is not more than the sum of—

(1) The empty weight determined under § 23.29;

continuous power.

(Amdt. 23–2, Eff. 8/1/65); (Amdt. 23–7, Eff. 9/14/69); (Amdt. 23–21, Eff. 3/1/78); (Amdt. 23–34, Eff. 2/17/87); [(Amdt. 23–45, Eff. 9/7/93)]

§ 23.29 Empty weight and corresponding center of gravity.

(a) The empty weight and corresponding center of gravity must be determined by weighing the airplane with—

(1) Fixed ballast;

(2) Unusable fuel determined under § 23.959; and

(3) Full operating fluids, including—

(i) Oil;

(ii) Hydraulic fluid; and

(iii) Other fluids required for normal operation of airplane systems, except potable water, lavatory precharge water, and water intended for injection in the engines.

(b) The condition of the airplane at the time of determining empty weight must be one that is well defined and can be easily repeated.

(Amdt. 23–21, Eff. 3/1/78)

§ 23.31 Removable ballast.

Removable ballast may be used in showing compliance with the flight requirements of this subpart, if—

(a) The place for carrying ballast is properly designed and installed, and is marked under § 23.1557; and

(b) Instructions are included in the Airplane Flight Manual, approved manual material, or markings and placards, for the proper placement of the removable ballast under each loading condition for which removable ballast is necessary.

(Amdt. 23–13, Eff. 10/23/72)

throttle or at maximum allowable takeoff manifold pressure, to a speed not greater than the maximum allowable takeoff r.p.m.; and

(2) During a closed throttle glide at the placarded "never-exceed speed", the propeller may not cause an engine speed above 110 percent of maximum continuous speed.

(c) *Controllable pitch propellers without constant speed controls.* Each propeller that can be controlled in flight, but that does not have constant speed controls, must have a means to limit the pitch range so that—

(1) The lowest possible pitch allows compliance with paragraph (b)(1) of this section; and

(2) The highest possible pitch allows compliance with paragraph (b)(2) of this section.

(d) *Controllable pitch propellers with constant speed controls.* Each controllable pitch propeller with constant speed controls must have—

(1) With the governor in operation, a means at the governor to limit the maximum engine speed to the maximum allowable takeoff r.p.m.; and

(2) [With the governor inoperative, the propeller blades at the lowest possible pitch, with takeoff power, the airplane stationary, and no wind, either—

(i) A means to limit the maximum engine speed to 103 percent of the maximum allowable takeoff r.p.m., or

(ii) For an engine with an approved overspeed, a means to limit the maximum engine and propeller speed to not more than the maximum approved overspeed.]

[(Amdt. 23–45, Eff. 9/7/93)]

PERFORMANCE

§ 23.45 General.

(a) Unless otherwise prescribed, the performance requirements of this subpart must be met for still air; and

(1) Standard atmospheric conditions for normal, utility, and acrobatic category airplanes; or

the approved power or thrust, less—

(1) Installation losses; and

(2) The power or equivalent thrust absorbed by the accessories and services appropriate to the particular ambient atmospheric conditions and the particular flight condition.

(d) [The performance, as affected by engine power or thrust, must be based on a relative humidity of—

(1) 80 percent, at and below standard temperature; and

(2) 34 percent, at and above standard temperature plus 50°F.

(3) Between the two temperatures listed in paragraphs (d)(1) and (d)(2) of this section, the relative humidity must vary linearly.]

[(e)] For commuter category airplanes, the following also apply:

(1) Unless otherwise prescribed, the applicant must select the takeoff, en route, approach, and landing configurations for the airplane;

(2) The airplane configuration may vary with weight, altitude, and temperature, to the extent they are compatible with the operating procedures required by paragraph [(e)](3) of this section;

(3) Unless otherwise prescribed, in determining the critical-engine-inoperative takeoff performance, takeoff flight path, the accelerate-stop distance, takeoff distance, and landing distance, changes in the airplane's configuration, speed, power, and thrust must be made in accordance with procedures established by the applicant for operation in service;

(4) Procedures for the execution of missed approaches and balked landings associated with the conditions prescribed in §§ 23.67(e)(3) and 23.77(c) must be established; and

(5) The procedures established under paragraphs [(e)](3) and (4) of this section must—

(i) Be able to be consistently executed by a crew of average skill;

(ii) Use methods or devices that are safe and reliable; and

the minimum steady speed, in knots (CAS), at which the airplane is controllable, with the—

(1) Applicable power or thrust condition set forth in paragraph (e) of this section;

(2) Propellers in the takeoff position;

(3) Landing gear extended;

(4) Wing flaps in the landing position;

(5) Cowl flaps closed;

(6) Center of gravity in the most unfavorable position within the allowable landing range; and

(7) Weight used when V_{SO} is being used as a factor to determine compliance with a required performance standard.

(b) [Except as provided in § 23.49(c), V_{SO} at maximum weight may not exceed 61 knots for—]

(1) Single-engine airplanes; and

(2) Multiengine airplanes of 6,000 pounds or less maximum weight that cannot meet the minimum rate of climb specified in § 23.67(b) with the critical engine inoperative.

[(c) All single-engine airplanes, and those multiengine airplanes of 6,000 pounds or less maximum weight with a V_{SO} of more than 61 knots that do not meet the requirements of § 23.67(b)(2)(i), must comply with § 23.562(d).]

([d]) V_{S1} is the calibrated stalling speed, if obtainable, or the minimum steady speed, in knots, at which the airplane is controllable with the—

(1) Applicable power or thrust condition set forth in paragraph (e) of this section;

(2) Propellers in the takeoff position;

(3) Airplane in the condition existing in the test in which V_{S1} is being used; and

(4) Weight used when V_{S1} is being used as a factor to determine compliance with a required performance standard.

([e]) V_{SO} and V_{S1} must be determined by flight tests, using the procedure specified in § 23.201.

([f]) The following power or thrust conditions must be used to meet the requirements of this section:

(1) For reciprocating engine-powered airplanes, engines idling, throttles closed or at not more than the power necessary for zero thrust at a

§ 23.51 Takeoff.

(a) For each airplane (except a skiplane for which landplane takeoff data has been determined under this paragraph and furnished in the Airplane Flight Manual) the distance required to take off and climb over a 50-foot obstacle must be determined with—

(1) The engines operating within approved operating limitations; and

(2) The cowl flaps in the normal takeoff position.

(b) The starting point for measuring seaplane and amphibian takeoff distance may be the point at which a speed of not more than three knots is reached.

(c) Takeoffs made to determine the data required by this section may not require exceptional piloting skill or exceptionally favorable conditions.

(d) For commuter category airplanes, takeoff performance and data as required by §§ 23.53 through 23.59 must be determined and included in the Airplane Flight Manual—

(1) For each weight, altitude, and ambient temperature within the operational limits selected by the applicant;

(2) For the selected configuration for takeoff;

(3) For the most unfavorable center of gravity position;

(4) With the operating engine within approved operating limitations;

(5) On a smooth, dry, hard surface runway; and

(6) Corrected for the following operational correction factors:

(i) Not more than 50 percent of nominal wind components along the takeoff path opposite to the direction of takeoff and not less than 150 percent of nominal wind components along the takeoff path in the direction of takeoff; and

(ii) Effective runway gradients.

(Amdt. 23–7, Eff. 9/14/78); (Amdt. 23–21, Eff. 3/1/78); (Amdt. 23–34, Eff. 2/17/87)

(1) For multiengine airplanes, the higher of—

(i) 1.1 V_{MC}; or

(ii) [Any lesser speed, not less than 1.2 V_{S1}, that is shown to be safe for continued flight or land-back, if applicable, under all conditions, including turbulence and complete failure of the critical engine.

(2) [For single engine airplanes, any speed, not less than 1.2 V_{S1}, that is shown to be safe under all conditions, including turbulence and complete engine failure.]

(c) For commuter category airplanes, the following apply:

(1) The takeoff decision speed, V_1, is the calibrated airspeed on the ground at which, as a result of engine failure or other reasons, the pilot is assumed to have made a decision to continue or discontinue the takeoff. The takeoff decision speed, V_1, must be selected by the applicant but may not be less than the greater of the following:

(i) 1.10 V_{S1};

(ii) 1.10 V_{MC} established in accordance with § 23.149;

(iii) A speed at which the airplane can be rotated for takeoff and shown to be adequate to safely continue the takeoff, using normal piloting skill, when the critical engine is suddenly made inoperative; or

(iv) V_{EF} plus the speed gained with the critical engine inoperative during the time interval between the instant that the critical engine is failed and the instant at which the pilot recognizes and reacts to the engine failure as indicated by the pilot's application of the first retarding means during the accelerate-stop determination of § 23.55.

(2) The takeoff safety speed, V_2, in terms of calibrated airspeed, must be selected by the applicant so as to allow the gradient of climb required in § 23.67 but must not be less than V_1 or less than 1.2 V_{S1}.

(3) The critical engine failure speed, V_{EF}, is the calibrated airspeed at which the critical engine is assumed to fail. V_{EF} must be selected

out speed, V_2, before reaching a height of 35 feet above the takeoff surface.

(5) For any given set of conditions, such as weight, altitude, configuration, and temperature, a single value of V_R must be used to show compliance with both the one-engine-inoperative takeoff and all-engines-operating takeoff requirements:

(i) One-engine-inoperative takeoff determined in accordance with § 23.57; and

(ii) All-engines-operating takeoff determined in accordance with § 23.59.

(6) The one-engine-inoperative takeoff distance, using a normal rotation rate at a speed of 5 knots less than V_R established in accordance with paragraphs (c)(4) and (5) of this section, must be shown not to exceed the corresponding one-engine-inoperative takeoff distance determined in accordance with §§ 23.57 and 23.59 using the established V_R. The takeoff distance determined in accordance with § 23.59 and the takeoff must be safely continued from the point at which the airplane is 35 feet above the takeoff surface at a speed not less than 5 knots less than the established V_2 speed.

(7) The applicant must show, with all engines operating, that marked increases in the scheduled takeoff distances determined in accordance with § 23.59 do not result from over-rotation of the airplane and out-of-trim conditions.

(Amdt. 23–34, Eff. 2/17/87); [(Amdt. 23–45, Eff. 9/7/93)]

§ 23.55 Accelerate-stop distance.

For each commuter category airplane, the accelerate-stop distance must be determined as follows:

(a) The accelerate-stop distance is the sum of the distances necessary to—

(1) Accelerate the airplane from a standing start of V_1; and

(2) Come to a full stop from the point at which V_1 is reached assuming that in the case of engine failure, the pilot has decided to stop

(3) Is such that exceptional skill is not required to control the airplane.

(Amdt. 23–34, Eff. 2/17/87)

§ 23.57 Takeoff path.

For each commuter category airplane, the takeoff path is as follows:

(a) The takeoff path extends from a standing start to a point in the takeoff at which the airplane is 1,500 feet above the takeoff surface or at which the transition from the takeoff to the en route configuration is completed, whichever point is higher; and

(1) The takeoff path must be based on the procedures prescribed in § 23.45;

(2) The airplane must be accelerated on the ground to V_{EF} at which point the critical engine must be made inoperative and remain inoperative for the rest of the takeoff; and

(3) After reaching V_{EF}, the airplane must be accelerated to V_2.

(b) During the acceleration to speed V_2, the nose gear may be raised off the ground at a speed not less than V_R. However, landing gear retraction may not be initiated until the airplane is airborne.

(c) During the takeoff path determination, in accordance with paragraphs (a) and (b) of this section—

(1) The slope of the airborne part of the takeoff path must be positive at each point;

(2) The airplane must reach V_2 before it is 35 feet above the takeoff surface, and must continue at a speed as close as practical to, but not less than V_2, until it is 400 feet above the takeoff surface;

(3) At each point along the takeoff path, starting at the point at which the airplane reaches 400 feet above the takeoff surface, the available gradient of climb may not be less than—

(i) 1.2 percent for two-engine airplanes;

(ii) 1.5 percent for three-engine airplanes;

(iii) 1.7 percent for four-engine airplanes; and by the segmental method—

(1) The segments must be clearly defined and must be related to the distinct changes in the configuration, power or thrust, and speed;

(2) The weight of the airplane, the configuration, and the power or thrust must be constant throughout each segment and must correspond to the most critical condition prevailing in the segment;

(3) The flight path must be based on the airplane's performance without ground effect;

(4) The takeoff path data must be checked by continuous demonstrated takeoffs up to the point at which the airplane is out of ground effect and its speed is stabilized to ensure that the path is conservative relative to the continuous path; and

(5) The airplane is considered to be out of the ground effect when it reaches a height equal to its wing span.

(Amdt. 23–34, Eff. 2/17/87)

§ 23.59 Takeoff distance and takeoff run.

For each commuter category airplane—

(a) Takeoff distance is the greater of—

(1) The horizontal distance along the takeoff path from the start of the takeoff to the point at which the airplane is 35 feet above the takeoff surface as determined under § 23.57; or

(2) With all engines operating, 115 percent of the horizontal distance along the takeoff path, with all engines operating, from the start of the takeoff to the point at which the airplane is 35 feet above the takeoff surface, as determined by a procedure consistent with § 23.57.

(b) If the takeoff distance includes a clearway, the takeoff run is the greater of—

(1) The horizontal distance along the takeoff path from the start of the takeoff to a point equidistant between the point at which V_{LOF} is reached and the point at which the airplane is 35 feet above the takeoff surface as determined under § 23.57; or

(Amdt. 23–34, Eff. 2/17/87)

§ 23.61 Takeoff flight path.

For each commuter category airplane, the takeoff flight path must be determined as follows:

(a) The takeoff flight path begins 35 feet above the takeoff surface at the end of the takeoff distance determined in accordance with § 23.59.

(b) The net takeoff flight path data must be determined so that that they represent the actual takeoff flight paths, as determined in accordance with § 23.57 and with paragraph (a) of this section, reduced at each point by a gradient of climb equal to—

(1) 0.8 percent for two-engine airplanes;

(2) 0.9 percent for three-engine airplanes; and

(3) 1.0 percent for four-engine airplanes.

(c) The prescribed reduction in climb gradient may be applied as an equivalent reduction in acceleration along that part of the takeoff flight path at which the airplane is accelerated in level flight.

(Amdt. 23–34, Eff. 2/17/87)

§ 23.65 Climb: all engines operating.

(a) [Each airplane must have a steady angle of climb at sea level of at least 1:12 for landplanes or 1:15 for seaplanes and amphibians with—

(1) A speed not less than 1.2 V_{S1};

(2) Not more than maximum continuous power on each engine;

(3) The landing gear retracted;

(4) The wing flaps in the takeoff position; and

(5) The cowl flaps or other means for controlling the engine cooling air supply in the position used in the cooling tests required by §§ 23.1041 through 23.1047.]

(b) Each airplane with engines for which the takeoff and maximum continuous power ratings are identical and that has fixed-pitch, two-position, or similar propellers, may use a lower propeller pitch setting than that allowed by § 23.33 to obtain rated engine r.p.m. at V_X, if—

(c) Each turbine engine-powered airplane must be able to maintain a steady gradient of climb at least 4 percent at a pressure altitude of 5,000 feet and a temperature of 81° F (standard temperature plus 40° F) with the airplane in the configuration prescribed in paragraph (a) of this section.

(d) In addition for commuter category airplanes, performance data must be determined for variations in weight, altitude, and gravity for which approval is requested.

(Amdt. 23–7, Eff. 9/14/69); (Amdt. 23–21, Eff. 3/1/78); (Amdt. 23–34, Eff. 2/17/87); [(Amdt. 23–45, Eff. 9/7/93)]

§ 23.67 Climb: one engine inoperative.

(a) For normal, utility, and acrobatic category, reciprocating engine-powered multiengine airplanes, one-engine-inoperative climb gradients must be determined with the—

(1) Critical engine inoperative, and its propeller in the minimum drag position;

(2) Remaining engines at not more than maximum continuous power or thrust;

(3) Landing gear retracted;

(4) Wing flaps in the most favorable position; and

(5) Means for controlling the engine cooling air supply in the position used in the engine cooling tests required by §§ 23.1041 through 23.1047.

(b) For normal, utility, and acrobatic category reciprocating engine-powered multiengine airplanes, the following apply:

(1) [Each airplane of more than 6,000 pounds maximum weight must be able to maintain a steady climb gradient of at least 1.5 percent at a pressure altitude of 5,000 feet at a speed not less than 1.2 V_{S1} and at standard temperature (41°F) with the airplane in the configuration prescribed in paragraph (a) of this section.

(2) [For each airplane of 6,000 pounds or less maximum weight, the following apply:

[(i) Each airplane that meets the requirements of § 23.562(d), or that has a V_{SO} of knots must be able to maintain the steady climb gradient prescribed in paragraph (b)(1) of this section.]

(c) For normal, utility, and acrobatic category turbine engine-powered mutiengine airplanes the following apply:

(1) The steady climb gradient must be determined at each weight, altitude, and ambient temperature within the operational limits established by the applicant, with the airplane in the configuration prescribed in paragraph (a) of this section.

(2) Each airplane must be able to maintain at least the following climb gradients with the airplane in the configuration prescribed in paragraph (a) of this section:

(i) 1.5 percent at a pressure altitude of 5,000 feet at a speed not less than 1.2 V_{S1}, and at standard temperature (41° F); and

(ii) 0.75 percent at a pressure altitude of 5,000 feet at a speed not less than 1.2 V_{S1} and 81° F (standard temperature plus 40° F).

(3) The minimum climb gradient specified in paragraphs (c)(2)(i) and (ii) of this section must vary linearly between 41° F and 81° F and must change at the same rate up to the maximum operating temperature approved for the airplane.

(d) For all multiengine airplanes, the speed for best rate of climb with one engine inoperative must be determined.

(e) For commuter category airplanes, the following apply:

(1) *Takeoff climb:* The maximum weight at which the airplane meets the minimum climb performance specified in (i) and (ii) of this paragraph must be determined for each altitude and ambient temperature within the operating limitations established for the airplane, out of ground effect in free air, with the airplane in the takeoff configuration, with the most critical center of gravity, the critical engine inoperative, the remaining engines at the maximum takeoff power or thrust, and the propeller of the inoperative engine windmilling with the propeller controls in the normal position, except that, if an approved

the flight path; and

(ii) *Takeoff, landing gear retracted.* The minimum steady gradient of climb must not be less than 2 percent for two-engine airplanes, 2.3 percent for three-engine airplanes, and 2.6 percent for four-engine airplanes at the speed V_2, until the airplane is 400 feet above the takeoff surface. For airplanes with fixed landing gear, this requirement must be met with the landing gear extended.

(2) *En route climb:* The maximum weight must be determined for each altitude and ambient temperature within the operational limits established for the airplane, at which the steady gradient of climb is not less than 1.2 percent for two-engine airplanes, 1.5 percent for three-engine airplanes, and 1.7 percent for four-engine airplanes at a height of 1,500 feet above the takeoff surface, with the airplane in the en route configuration, the critical engine inoperative, the remaining engine at the maximum continuous power or thrust, and the most unfavorable center of gravity.

(3) *Approach:* In the approach configuration corresponding to the normal all-engines-operating procedure in which V_{S1} for this configuration does not exceed 110 percent of the V_{S1} for the related landing configuration, the steady gradient of climb may not be less than 2.1 percent for two-engine airplanes, 2.4 percent for three-engine airplanes, and 2.7 percent for four-engine airplanes, with—

(i) The critical engine inoperative and the remaining engines at the available takeoff power or thrust;

(ii) The maximum landing weight; and

(iii) A climb speed established in connection with the normal landing procedures but not exceeding 1.5 V_{S1}.

(Amdt. 23–7, Eff. 9/14/69); (Amdt. 23–21, Eff. 3/1/78); (Amdt. 23–34, Eff. 2/17/87); (Amdt. 23–39, Eff. 5/2/90); (Amdt. 23–42, Eff. 2/4/91); **[**(Amdt. 23–44, Eff. 8/18/93)**]**

(a) A steady approach with a calibrated airspeed of not less than 1.3 V_{S1} must be maintained down to the 50-foot height and—

(1) The steady approach must be at a gradient of descent not greater than 5.2 percent (3°) down to the 50-foot height.

(2) In addition, an applicant may demonstrate by tests that a maximum steady approach gradient steeper than 5.2 percent, down to the 50-foot height, is safe. The gradient must be established as an operating limitation and the information necessary to display the gradient must be available to the pilot by an appropriate instrument.

(b) The landing may not require more than average piloting skill when landing during the atmospheric conditions expected to be encountered in service, including crosswinds and turbulence.

(c) The landing must be made without excessive vertical acceleration or tendency to bounce, nose over, ground loop, porpoise, or water loop.

(d) It must be shown that a safe transition to the balked landing conditions of § 23.77 can be made from the conditions that exist at the 50-foot height.

(e) The pressures on the wheel braking system may not exceed those specified by the brake manufacturer.

(f) Means other than wheel brakes may be used if that means—

(1) Is safe and reliable;

(2) Is used so that consistent results can be expected in service; and

(3) Is such that no more than average skill is required to control the airplane.

(g) If any device is used that depends on the operation of any engine, and the landing distance would be increased when a landing is made with that engine inoperative, the landing distance must be determined with that engine inoperative unless the use of other compensating means will result in a landing distance not more than that with each engine operating.

(h) In addition, for commuter category airplanes, the following apply:

(3) The landing distance data must include correction factors for not more than 50 percent of the nominal wind components along the landing path opposite to the direction of landing and not less than 150 percent of the nominal wind components along the landing path in the direction of landing.

(Amdt. 23–7, Eff. 9/14/69); (Amdt. 23–21, Eff. 3/1/78); (Amdt. 23–34, Eff. 2/17/87); (Amdt. 23–42, Eff. 2/4/91)

§ 23.77 Balked landing.

(a) For balked landings, each normal, utility, and acrobatic category airplane must be able to maintain a steady angle of climb at sea level of at least 1:30 with—

(1) Takeoff power on each engine;

(2) The landing gear extended; and

(3) The wing flaps in the landing position, except that if the flaps may safely be retracted in two seconds or less without loss of altitude and without sudden changes of angle of attack or exceptional piloting skill, they may be retracted.

(b) Each normal, utility, and acrobatic category turbine engine-powered airplane must be able to maintain a steady rate of climb of at least zero at a pressure altitude of 5,000 feet at 81° F (standard temperature plus 40° F), with the airplane in the configuration prescribed in paragraph (a) of this section.

(c) For each commuter category airplane, with all engines operating, the maximum weight must be determined with the airplane in the landing configuration for each altitude and ambient temperature within the operational limits established for the airplane, with the most unfavorable center of gravity and out-of-ground effect in free air, at which the steady gradient of climb will not be less than 3.3 percent with—

(1) The engines at the power or thrust that is available 8 seconds after initiation of movement of the power or thrust controls from the

FLIGHT CHARACTERISTICS

§ 23.141 General.

[The airplane must meet the requirements of §§ 23.143 through 23.253 at all practical loading conditions and operating altitudes for which certification has been requested, not exceeding the maximum operating altitude established under § 23.1527, and without requiring exceptional piloting skill, alertness, or strength.]

(Amdt. 23–7, Eff. 9/14/69); (Amdt. 23–17, Eff. 2/1/77); [(Amdt. 23–45, Eff. 9/7/93)]

CONTROLLABILITY AND MANUEVERABILITY

§ 23.143 General.

(a) The airplane must be safely controllable and maneuverable during—

(1) Takeoff;

(2) Climb;

(3) Level flight;

(4) [Descent]; and

(5) Landing (power on and power off with the wing flaps extended and retracted).

(b) It must be possible to make a smooth transition from one flight condition to another (including turns and slips) without danger of exceeding the limit load factor, under any probable operating condition, (including, for multiengine airplanes, those conditions normally encountered in the sudden failure of any engine).

(c) If marginal conditions exist with regard to required pilot strength, the ''strength of pilots'' limits must be shown by quantitative tests. In no case may the limits exceed those prescribed in the following table:

Values in pounds of force as applied to the [stick,] control wheel, or rudder pedals	Pitch	Roll	Yaw
(a) For temporary application:			
Stick	60	30	....
[Wheel (two hands on rim)	75	60]	....

§ 23.145 Longitudinal control.

(a) [With the airplane as nearly as possible in trim at 1.3 V_{S1}, it must be possible, at speeds below the trim speed, to pitch the nose downward so that the rate of increase in airspeed allows prompt acceleration to the trim speed with—

(1) Maximum continuous power on each engine;

(2) Power off; and

(3) Wing flap and landing gear—

(i) retracted, and

(ii) extended.

(b) No change in trim or exertion of more control force, as specified in § 23.143(c), than can be readily applied with one hand for a short period of time may be required for the following maneuvers:

(1) With the landing gear extended, the flaps retracted, and the airplane as nearly as possible in trim at 1.4 V_{S1}, extend the flaps as rapidly as possible and allow the airspeed to transition from 1.4 V_{S1}, to 1.4 V_{SO}:

(i) With power off; and

(ii) With the power necessary to maintain level flight in the initial condition.

(2) With the landing gear and flaps extended—

(i) With power off and the airplane as nearly as possible in trim at 1.3 V_{SO}, quickly apply takeoff power or thrust and retract the flaps as rapidly as possible to the recommended go-around setting while attaining and maintaining, as a minimum, the speed used to show compliance with § 23.77. Retract the gear when positive rate of climb is established; and

(ii) With power off and in level flight at 1.1 V_{SO}, and the airplane as nearly as possible in trim at 1.2 V_{SO}, it must be possible to maintain approximately level flight while retracting the flaps as rapidly as possible with simultaneous application of not more than maximum continuous power. If gated flap positions are provided, the airplane may be retrimmed between each stage of retraction, and the airplane may accelerate to a speed retracted, and the airplane as nearly as possible in trim at 1.4 V_S, apply takeoff power rapidly while maintaining the same airspeed.

(5) With power off, landing gear and flaps extended, and the airplane as nearly as possible in trim at 1.4 V_{SO}, obtain and maintain airspeeds between 1.1 V_{SO} and either 1.7 V_{SO} or V_{FE}, whichever is lower.

(c) At speeds above V_{MO}/M_{MO} and up to V_D/M_D, a maneuvering capability of 1.5g must be demonstrated to provide a margin to recover from upset or inadvertent speed increase.

(d) It must be possible, with a pilot control force of not more than 10 pounds, to maintain a speed of not more than 1.3 V_{SO}, during a power-off glide with landing gear and wing flaps extended, for any weight of the airplane, up to and including the maximum weight.

(e) By using normal flight and power controls, except as otherwise noted in paragraphs (e)(1) and (e)(2) of this section, it must be possible to establish a zero rate of descent at an attitude suitable for a controlled landing without exceeding the operational and structural limitations of the airplane, as follows:

(1) For single-engine and multiengine airplanes, without the use of the primary longitudinal control system.

(2) For multiengine airplanes—

(i) Without the use of the primary directional control; and

(ii) If a single failure of any one connecting or transmitting link would affect both the longitudinal and directional primary control system, without the primary longitudinal and directional control system.]

(Amdt. 23–14, Eff. 12/20/73); (Amdt. 23–17, Eff. 2/1/77); [(Amdt. 23–45, Eff. 9/7/93)]

§ 23.147 Directional and lateral control.

[For each multiengine airplane, it must be possible, while holding the wings level within 5 degrees, to make sudden changes in heading safely in both directions. This must be shown at 1.4 V_{S1}

(1) Retracted; and

(2) Extended; and

(d) Flaps in the most favorable climb position.]

[(Amdt. 23–45, Eff. 9/7/93)]

§ 23.149 Minimum control speed.

(a) [V_{MC} is the calibrated airspeed at which, when the critical engine is suddenly made inoperative, it is possible to maintain control of the airplane with that engine still inoperative and then maintain straight flight at the same speed with an angle of bank of not more than 5 degrees. The ability to maintain straight and level flight at V_{MC} in a static condition with a bank angle of not more than 5 degrees must also be demonstrated. The method used to simulate critical engine failure must represent the most critical mode of powerplant failure, with respect to controllability expected in service.

(b) V_{MC} may not exceed 1.2 V_{S1}, where V_{S1} is determined at the maximum takeoff weight, with—

(1) Maximum available takeoff power or thrust on the engines;

(2) The most unfavorable center of gravity;

(3) The airplane trimmed for takeoff;

(4) The maximum sea level takeoff weight, or any lesser weight necessary to show V_{MC};

(5) The airplane in the most critical takeoff configuration, with the propeller controls in the recommended takeoff position and the landing gear retracted; and

(6) The airplane airborne and the ground effect negligible.

(c) A minimum speed to intentionally render the critical engine inoperative must be established and designated as the safe, intentional, one-engine-inoperative speed, V_{SSE}.]

(d) At V_{MC}, the rudder pedal force required to maintain control may not exceed 150 pounds, and it may not be necessary to reduce power or thrust of the operative engines. During [the maneuver], the airplane may not assume any dangerous attitude for which certification is requested. Safe entry speeds for these maneuvers must be determined.

§ 23.153 Control during landings.

[It must be possible, while in the landing configuration, to safely complete a landing without exceeding the one hand control force specified in § 23.143(c) following an approach to land—

(a) At a speed 5 knots less than the speed used in complying with the requirements of § 23.75 and with the airplane in trim, or as nearly as possible in trim, and without the trimming control being moved throughout the maneuver;

(b) At an approach gradient equal to the steepest recommended for operational use; and

(c) With only those power or thrust changes that would be made when landing normally from an approach at 1.3 V_{S1}.]

(Amdt. 23–14, Eff. 12/20/73); [(Amdt. 23–45, Eff. 9/7/93)]

§ 23.155 Elevator control force in maneuvers.

(a) The elevator control force needed to achieve the positive limit maneuvering load factor may not be less than:

(1) For wheel controls, *W*/100 (where *W* is the maximum weight) or 20 pounds, whichever is greater, except that it need not be greater than 50 pounds; or

(2) For stick controls, *W*/140 (where *W* is the maximum weight) or 15 pounds, whichever is greater, except that it need not be greater than 35 pounds.

(b) [The requirement of paragraph (a) of this section must be met at 75 percent of maximum continuous power for reciprocating engines, or the maximum power or thrust selected by the applicant as an operating limitation for use during cruise for reciprocating or turbine engines, and with the wing flaps and landing gear retracted—

(1) In a turn, with the trim setting used for wings level flight at V_A; and

(2) In a turn with the trim setting used for the maximum wings level flight speed, except

9/7/93)]

§ 23.157 Rate of roll.

(a) *Takeoff.* It must be possible, using a favorable combination of controls, to roll the airplane from a steady 30° banked turn through an angle of 60°, so as to reverse the direction of the turn within:

(1) For an airplane of 6,000 pounds or less maximum weight, 5 seconds from initiation of roll; and

(2) For an airplane of over 6,000 pounds maximum weight, $(W + 500)/1{,}300$ seconds, [but not more than 10 seconds,] where W is the weight in pounds.

(b) [The requirement of paragraph (a) of this section must be met when rolling the airplane in each direction with—

(1) Flaps in the takeoff position;

(2) Landing gear retracted;

(3) For a single-engine airplane, at maximum takeoff power; and for a multiengine airplane with the critical engine inoperative and the propeller in the minimum drag position, and the other engines at maximum takeoff power; and

(4) The airplane trimmed at a speed equal to the greater of 1.2 V_{S1} or 1.1 V_{MC}, or as nearly as possible in trim for straight flight.]

(c) *Approach.* It must be possible using a favorable combination of controls, to roll the airplane from a steady 30° banked turn through an angle of 60°, so as to reverse the direction of the turn within:

(1) For an airplane of 6,000 pounds or less maximum weight, 4 seconds from initiation of roll; and

(2) For an airplane of over 6,000 pounds maximum weight, $(W + 2{,}800)/2{,}200$ seconds, [but not more than 7 seconds,] where W is the weight in pounds.

(d) The requirement of paragraph (c) must be met when rolling the airplane in either direction in the following conditions:

(1) Flaps extended;

(2) Landing gear extended;

TRIM

§ 23.161 Trim.

(a) *General.* Each airplane must meet the trim requirements of this section after being trimmed, and without further pressure upon, or movement of, the primary controls or their corresponding trim controls by the pilot or the automatic pilot.

(b) *Lateral and directional trim.* The airplane must maintain lateral and directional trim in level flight with the landing gear and wing flaps retracted as follows:

(1) For normal, utility, and acrobatic category airplanes at a speed of 0.9 V_H, V_C, or V_{MO}, whichever is the lower; and

(2) For commuter category airplanes, at a speed of V_H or V_{MO}/M_{MO}, whichever is lower.

(c) *Longitudinal trim.* The airplane must maintain longitudinal trim under each of the following conditions, except that it need not maintain trim at a speed greater than V_{MO}/M_{MO}:

(1) A climb with maximum continuous power at—

(i) The speed used in determining the climb performance required by § 23.65 of this part with the landing gear retracted, and the flaps in the takeoff position; and

(ii) The recommended all-engines-operating climb speed specified in § 23.1585(a)(2)(i) of this part.

(2) An approach at a gradient of descent of 5.2 percent (3°) with the landing gear extended, and with—

(i) Flaps retracted and at a speed of 1.4 V_{S1}; and

(ii) The applicable airspeed and flap position used in showing compliance with § 23.75.

(3) Level flight at any speed with the landing gear and wing flaps retracted as follows:

(i) For normal, utility, and acrobatic category airplanes, at any speeds from the lesser of V_H and V_{NO} or V_{MO}, as applicable, to 1.4 V_{S1}; and at the speed used in complying with § 23.67 for normal, utility, and acrobatic categories and at a speed between V_Y and 1.4 V_{S1} for commuter category with—

(1) The critical engine inoperative, and if applicable, its propeller in the minimum drag position;

(2) The remaining engines at maximum continuous power;

(3) The landing gear retracted;

(4) Wing flaps in the position selected for showing compliance with § 23.67 for normal, utility, and acrobatic category airplanes and wing flaps retracted for commuter category airplanes.

(5) An angle of bank of not more than 5°.

(Amdt. 23–7, Eff. 9/14/69); (Amdt. 23–14, Eff. 12/20/73); (Amdt. 23–21, Eff. 3/1/78); (Amdt. 23–34, Eff. 2/1/77); (Amdt. 23–42, Eff. 2/4/91)

STABILITY

§ 23.171 General.

The airplane must be longitudinally, directionally, and laterally stable under §§ 23.173 through 23.181. In addition, the airplane must show suitable stability and control "feel" (static stability) in any condition normally encountered in service, if flight tests show it is necessary for safe operation.

§ 23.173 Static longitudinal stability.

Under the conditions specified in § 23.175 and with the airplane trimmed as indicated, the characteristics of the elevator control forces and the friction within the control system must be as follows:

(a) A pull must be required to obtain and maintain speeds below the specified trim speed and a push required to obtain and maintain speeds above the specified trim speed. This must be shown at any speed that can be obtained, except that speeds requiring a control force in excess of 40 pounds or speeds above the maximum allowable speed or

and

(2) For commuter category airplanes, the airspeed must return to within ±7.5 percent of the original trim airspeed for the cruising condition specified in § 23.175(b).

(c) The stick force must vary with speed so that any substantial speed change results in a stick force clearly perceptible to the pilot.

(Amdt. 23–14, Eff. 12/20/73); (Amdt. 23–34, Eff. 2/17/87)

§ 23.175 Demonstration of static longitudinal stability.

Static longitudinal stability must be shown as follows:

(a) *Climb.* The stick force curve must have a stable slope, at speeds between 85 and 115 percent of the trim speed, with—

(1) Flaps in the climb position;

(2) Landing gear retracted;

(3) [All reciprocating engines operating at maximum continuous power, or turbine engines operating at the maximum power selected by the applicant as an operating limitation for use during climb; and]

(4) The airplane trimmed for V_Y, except that the speed need not be less than 1.4 V_{S1}.

(b) *Cruise—Landing gear retracted (or fixed gear).* (1) For the cruise conditions specified in paragraphs (b)(2) and (3) of this section, the following apply:

(i) The speed need not be less than 1.3 V_{S1}.

(ii) For airplanes with V_{NE} established under § 23.1505(a), the speed need not be greater than V_{NE}.

(iii) For airplanes with V_{MO}/M_{MO} established under § 23.1505(c), the speed need not be greater than a speed midway between V_{MO}/M_{MO} and the lesser of V_D/M_D or the speed demonstrated under § 23.251, except that for altitudes where Mach number in the limiting factor, the speed need not exceed that cor-

For commuter category airplanes, the stick force curve must have a stable slope for a speed range of 50 knots from the trim speed, except that the speeds need not exceed V_{FC}/M_{FC} or be less than 1.4 V_{S1} and this speed range is considered to begin at the outer extremes of the friction band with a stick force not to exceed 50 pounds. In addition, for commuter category airplanes, V_{FC}/M_{FC} may not be less than a speed midway between V_{MO}/M_{MO} and V_{DF}/M_{DF}, except that, for altitudes where Mach number is the limiting factor, M_{FC} need not exceed the Mach number at which effective speed warning occurs. These requirements for all categories of airplane must be met with—

(i) Flaps retracted.

(ii) Seventy-five percent of maximum continuous power for reciprocating engines or, for turbine engines, the maximum cruising power or thrust selected by the applicant as an operating limitation, except that the power need not exceed that required at V_{NE} for airplanes with V_{NE} established under § 23.1505(a), or that required at V_{MO}/M_{MO} for airplanes with V_{MO}/M_{MO} established under § 23.1505(c).

(iii) The airplane trimmed for level flight.

(3) *Low speed cruise.* The stick force curve must have a stable slope under all the conditions prescribed in paragraph (b)(2) of this section, except that the power is that required for level flight at a speed midway between 1.3 V_{S1} and the trim speed obtained in the high speed cruise condition under paragraph (b)(2) of this section.

(c) *Landing gear extended (airplanes with retractable gear).* The stick force curve must have a stable slope at all speeds with a range from 15 percent of the trim speed plus the resulting free return speed range below the trim speed, to the trim speed (except that the speed range need not include speeds less than 1.4 V_{S1} nor speeds greater than V_{LE}, with—

(1) Landing gear extended;

(2) Flaps retracted;

(3) 75 percent of maximum continuous power for reciprocating engines, or for turbine engines,

(2) Landing gear extended;

(3) [The airplane trimmed at a speed in compliance with § 23.161(c)(2);]

(4) Both power off and enough power to maintain a 3° angle of descent.

(Amdt. 23–7, Eff. 9/14/69); (Amdt. 23–14, Eff. 12/20/73); (Amdt. 23–17, Eff. 2/1/77); (Amdt. 23–34, Eff. 2/17/87); [(Amdt. 23–45, Eff. 9/7/93)]

§ 23.177 Static directional and lateral stability.

(a) *Three-control airplanes.* The stability requirements for three-control airplanes are as follows:

(1) [The static directional stability, as shown by the tendency to recover from a skid with the rudder free, must be positive for any landing gear and flap position appropriate to the takeoff, climb, cruise, approach, and landing configurations. This must be shown with symmetrical power up to maximum continuous power, and at speeds from 1.2 V_{S1} up to the maximum allowable speed for the condition being investigated in the takeoff, climb, cruise, and approach configurations. For the landing configuration, the power must be up to that necessary to maintain a three degree angle of descent in coordinated flight. The angle sideslip for these tests must be appropriate to the type of airplane. At larger angles of sideslip, up to that at which full rudder is used or a control force limit in § 23.143 is reached, whichever occurs first, and at speeds from 1.2 V_{S1} to V_A, the rudder pedal force must not reverse.

(2) The static lateral stability, as shown by the tendency to raise the low wing in a sideslip, must be positive for any landing gear and flap position. This must be shown with symmetrical power, up to 75 percent of maximum continuous power, at speeds above 1.2 V_{S1} in the takeoff configuration and 1.3 V_{S1} in other configurations, up to the maximum allowable speed for the configuration being investigated in the takeoff, climb, approach, and cruise configuations. For the landing configuration, the power must be up to that necessary to maintain a three degree angle

landing gear and flap positions, and for any symmetrical power conditions up to 50 percent of maximum continuous power, the aileron and rudder control movements and forces must increase steadily, but not necessarily in constant proportion, as the angle of slip is increased up to the maximum appropriate to the type of airplane. At larger slip angles, up to the angle at which the full rudder or aileron control is used or a control force limit contained in § 23.143 is obtained, the aileron and rudder control movements and forces must not reverse as the angle of sideslip is increased. Enough bank must accompany the sideslip to hold a constant heading. Rapid entry into, or recovery from, a maximum sideslip considered appropriate for the airplane must not result in uncontrollable flight characteristics.]

(b) *Two-control (or simplified control) airplanes.* The stability requirements for two-control airplanes are as follows:

(1) The directional stability of the airplane must be shown by showing that, in each configuration, it can be rapidly rolled from a 45° bank in one direction to a 45° bank in the opposite direction without showing dangerous skid characteristics.

(2) The lateral stability of the airplane must be shown by showing that it will not assume a dangerous attitude or speed when the controls are abandoned for two minutes. This must be done in moderately smooth air with the airplane trimmed for straight level flight at 0.9 V_H or V_C, whichever is lower, with flaps and landing gear retracted, and with a rearward center of gravity.

(Amdt. 23–21, Eff. 3/1/78); [(Amdt. 23–45, Eff. 9/7/93)]

§ 23.179 Instrumented stick force measurements.

[Removed]

[(Amdt. 23–45, Eff. 9/7/93)]

(2) In a fixed position.

(b) Any combined lateral-directional oscillations (''Dutch roll'') occurring between the stalling speed and the maximum allowable speed appropriate to the configuration of the airplane must be damped to 1/10 amplitude in 7 cycles with the primary controls—

(1) Free; and

(2) In a fixed position.

[(c) If it is determined that the function of a stability augmentation system, reference § 23.672, is needed to meet the flight characteristic requirements of this part, the primary control requirements of paragraphs (a)(2) and (b)(2) of this section are not applicable to the tests needed to verify the acceptability of that system.

[(d) During the conditions as specified in § 23.175, when the longitudinal control force required to maintain speeds differing from the trim speed by at least ±15 percent is suddenly released, the response of the airplane must not exhibit any dangerous characteristics nor be excessive in relation to the magnitude of the control force released. Any long-period oscillation of flight path, phugoid oscillation, that results must not be so unstable as to increase the pilot's workload or otherwise endanger the airplane.]

(Amdt. 23–21, Eff. 3/1/78); [(Amdt. 23–45, Eff. 9/7/93)]

STALLS

§ 23.201 Wings level stall.

(a) For an airplane with independently controlled roll and directional controls, it must be possible to produce and to correct roll by unreversed use of the rolling control and to produce and to correct yaw by unreversed use of the directional control, up to the time the airplane pitches.

(b) For an airplane with interconnected lateral and directional controls (2 controls) and for an airplane with only one of these controls, it must be possible to produce and correct roll by unreversed until the control reaches the stop or until the activation of an artificial stall barrier, for example, stick pusher. Normal use of the elevator control for recovery is allowed after the pitching motion has unmistakably developed or after the control has been held against the stop for not less than two seconds. In addition, engine power may not be increased for recovery until the speed has increased to approximately 1.2 V_{S1}.]

(d) Except where made inapplicable by the special features of a particular type of airplane, the following apply to the measurement of loss of altitude during a stall:

(1) The loss of altitude encountered in the stall (power on or power off) is the change in altitude (as observed on the sensitive altimeter testing installation) between the altitude at which the airplane pitches and the altitude at which horizontal flight is regained.

(2) [If power is required during stall recovery, the power used must be that used under the normal operating procedures selected by the applicant for this maneuver; however, the power used to regain level flight may not be increased until the speed has increased to approximately 1.2 V_{S1}.]

(e) During the recovery part of the maneuver, it must be possible to prevent more than 15° of roll or yaw by the normal use of controls.

(f) Compliance with the requirements of this section must be shown under the following conditions:

(1) *Wing flaps:* Full up, full down, and intermediate, if appropriate.

(2) *Landing gear:* Retracted and extended.

(3) *Cowl flaps:* Appropriate to configuration.

(4) [*Power:* Power off, and 75 percent maximum continuous power. If the power-to-weight ratio at 75 percent continuous power provides undesirable stall characteristics at extremely nose-high attitudes, the test may be accomplished with the power or thrust required for level flight in the landing configuration at maximum landing weight and a speed of 1.4 V_{SO}, but the power may not be less than 50 percent of maximum continuous power.

Turning flight and accelerated stalls must be demonstrated in flight tests as follows:

(a) Establish and maintain a coordinated turn in a 30° bank. Reduce speed by steadily and progressively tightening the turn with the elevator until the airplane is stalled or until the elevator has reached its stop. The rate of speed reduction must be constant, and—

(1) For a turning flight stall, may not exceed one knot per second; and

(2) For an accelerated stall, be 3 to 5 knots per second with steadily increasing normal acceleration.

(b) [When the stall has fully developed or the elevator has reached its stop, it must be possible to regain level flight by normal use of the flight controls but without increasing power, and without]

(1) Excessive loss of altitude;

(2) Undue pitchup;

(3) Uncontrollable tendency to spin;

(4) [Exceeding a bank angle of 60 degrees in the original direction of the turn or 30 degrees in the opposite direction in the case of turning flight stalls, and without exceeding a bank angle of 90 degrees in the original direction of the the turn or 60 degrees in the opposite direction in the case of accelerated stalls; and

(5) Exceeding the maximum permissible speed or allowable limit load factor.]

(c) Compliance with the requirements of this section must be shown with—

(1) *Wing flaps:* [Retracted, fully extended, and in each intermediate position, as appropriate;]

(2) *Landing gear:* Retracted and extended;

(3) *Cowl flaps:* Appropriate to configuration;

(4) *Power:* [Power or thrust off, and 75 percent maximum continuous power or thrust. If the power-to-weight ratio at 75 percent continuous power or thrust provides undesirable stall characteristics at extremely nose-high attitudes, the test may be accomplished with the power or thrust required for level flight in the landing configuration at maximum landing weight and a speed of 1.4 V_{SO}, but the power may not be

(a) A multiengine airplane may not display any undue spinning tendency and must be safely recoverable without applying power to the inoperative engine when stalled. The operating engines may be throttled back during the recovery from stall.

(b) Compliance with paragraph (a) of this section must be shown with—

(1) *Wing flaps:* [Retracted and set to the position used to show compliance with § 23.67.]

(2) *Landing gear:* Retracted.

(3) *Cowl flaps:* Appropriate to level flight critical engine inoperative.

(4) *Power:* Critical engine inoperative and the remaining engine(s) at 75 percent maximum continuous power or thrust or the power or thrust at which the use of maximum control travel just holds the wings laterally level in the approach to stall, whichever is lesser.

(5) *Propeller:* Normal inoperative position for the inoperative engine.

(6) *Trim:* [Level flight, critical engine inoperative, except that for an airplane of 6,000 pounds or less maximum weight that has a stalling speed of 61 knots or less and cannot maintain level flight with the critical engine inoperative, the airplane must be trimmed for straight flight, critical engine inoperative, at a speed as near 1.5 V_{S1} as practicable.]

(Amdt. 23–3, Eff. 11/11/65); (Amdt. 23–14, Eff. 12/20/73); [(Amdt. 23–45, Eff. 9/7/93)]

§ 23.207 Stall warning.

(a) There must be a clear and distinctive stall warning, with the flaps and landing gear in any normal position, in straight and turning flight.

(b) The stall warning may be furnished either through the inherent aerodynamic qualities of the airplane or by a device that will give clearly distinguishable indications under expected conditions of flight. However, a visual stall warning device that requires the attention of the crew within the cockpit is not acceptable by itself.

stall for the stall to be averted by action after the stall warning first occurs. In addition, when following the procedures of § 23.1585, the stall warning must not operate during a normal takeoff, a takeoff continued with one engine inoperative or approach to landing.]

(Amdt. 23–7, Eff. 9/14/69); [(Amdt. 23–45, Eff. 9/7/93)]

SPINNING

§ 23.221 Spinning.

(a) *Normal category.* Except as provided in paragraph (d) of this section, a single-engine, normal category airplane must demonstrate compliance with either the one-turn spin or the spin-resistant requirements of this paragraph.

(1) One-turn spin. The airplane must recover from a one-turn spin or a three-second spin, whichever takes longer, in not more than one additional turn after the controls have been applied for recovery. In addition—

(i) For both the flaps-retracted and flaps-extended conditions, the applicable airspeed limit and positive limit maneuvering load factor must not be exceeded;

(ii) There must be no excessive back pressure during the spin or recovery;

(iii) It must be impossible to obtain unrecoverable spins with any use of the flight or engine power controls either at the entry into or during the spin; and

(iv) For the flaps-extended condition, the flaps may be retracted during the recovery, but not before rotation has ceased.

(2) Spin resistant. The airplane must be demonstrated to be spin resistant by the following:

(i) During the stall maneuvers contained in § 23.201, the pitch control must be pulled back and held against the stop. Then, using ailerons and rudders in the proper direction, it must be possible to maintain wings-level flight within 15° of bank and to roll the airplane of 7 seconds or through a 360° heading change, whichever occurs first. If the 360° heading change is reached first, it must have taken no fewer than 4 seconds. This maneuver must be performed first with the ailerons in the neutral position, and then with the ailerons deflected opposite the direction of turn in the most adverse manner. Power or thrust and airplane configuration must be set in accordance with § 23.201(f) without change during the maneuver. At the end of 7 seconds or a 360° heading change, the airplane must respond immediately and normally to primary flight controls applied to regain coordinated, unstalled flight without reversal of control effect and without exceeding the temporary control forces specified by § 23.143(c); and

(iii) Compliance with §§ 23.201 and 23.203 must be demonstrated with the airplane in uncoordinated flight, corresponding to one ball width displacement on a slip-skid indicator, unless one ball width displacement cannot be obtained with full rudder, in which case the demonstration must be with full rudder applied.

(b) *Utility category.* A utility category airplane must meet the requirements of paragraph (a) of this section or the requirements of paragraph (c) of this section if approval for spinning is requested.

(c) *Acrobatic category.* An acrobatic category airplane must meet the following requirements:

(1) The airplane must recover from any point in a spin, in not more than one and one-half additional turns after normal recovery application of the controls. Prior to normal recovery application of the controls, the spin test must proceed for six turns or 3 seconds, whichever takes longer, with flaps retracted, and one turn or 3 seconds, whichever takes longer, with flaps extended. However, beyond 3 seconds, the spin may be discontinued when spiral characteristics appear with flaps retracted.

(2) For both the flaps-retracted and flaps-extended conditions, the applicable airspeed limit and positive limit maneuvering load factor may not be exceeded. For the flaps-extended condition, the flaps may be retracted during recovery,

as "characteristically incapable of spinning", this characteristic must be shown with—

(1) A weight five percent more than the highest weight for which approval is requested;

(2) A center of gravity at least three percent aft of the rearmost position for which approval is requested;

(3) An available elevator up-travel 4° in excess of that to which the elevator travel is to be limited for approval; and

(4) An available rudder travel 7°, in both directions, in excess of that to which the rudder travel is to be limited for approval.

(Amdt. 23–7, Eff. 9/14/69); (Amdt. 23–42, Eff. 2/4/91)

GROUND AND WATER HANDLING CHARACTERISTICS

§ 23.231 Longitudinal stability and control.

(a) A landplane may have no uncontrollable tendency to nose over in any reasonably expected operating condition, including rebound during landing or takeoff. Wheel brakes must operate smoothly and may not induce any undue tendency to nose over.

(b) A seaplane or amphibian may not have dangerous or uncontrollable porpoising characteristics at any normal operating speed on the water.

§ 23.233 Directional stability and control.

(a) [A 90 degree cross-component of wind velocity, demonstrated to be safe for taxiing, takeoff and landing must be established and must not be less than 0.2 V_{SO}.

(b) [The airplane must be satisfactorily controllable in power-off landings at normal landing speed, without using brakes or engine power to maintain a straight path until the speed has decreased to at least 50 percent of the speed at touchdown.]

(c) The airplane must have adequate directional control during taxiing.

satisfactory characteristics and the shock-absorbing mechanism must not damage the structure of the airplane when the airplane is taxied on the roughest ground that may be reasonably expected in normal operation, and when takeoffs and landings are performed on unpaved runways having the roughest surface that may reasonably be expected in normal operation.

[(b) A wave height, demonstrated to be safe for operation, and any necessary water handling procedures for seaplanes and amphibians, must be established.]

[(Amdt. 23–45, Eff. 9/7/93)]

§ 23.239 Spray characteristics.

Spray may not dangerously obscure the vision of the pilots or damage the propellers or other parts of a seaplane or amphibian at any time during taxiing, takeoff, and landing.

MISCELLANEOUS FLIGHT REQUIREMENTS

§ 23.251 Vibration and buffeting.

[There must be no vibration or buffeting severe enough to result in structural damage, and each part of the airplane must be free from excessive vibration, under any appropriate speed and power conditions up to V_D/M_D. In addition, there must be no buffeting in any normal flight condition severe enough to interfere with the satisfactory con-

... the following speed increase and recovery characteristics must be met:

(a) [Operating conditions and characteristics likely to cause inadvertent speed increases (including upsets in pitch and roll) must be simulated with the airplane trimmed at any likely speed up to V_{MO}/M_{MO}. These conditions and characteristics include gust upsets, inadvertent control movements, low stick force gradients in relation to control friction, passenger movement, leveling off from climb, and descent from Mach to airspeed limit altitude.

(b) [Allowing for pilot reaction time after occurrence of the effective inherent or artificial speed warning specified in § 23.1303, it must be shown that the airplane can be recovered to a normal attitude and its speed reduced to V_{MO}/M_{MO}, without—]

(1) Exceptional piloting strength or skill;

(2) Exceeding V_D/M_D, the maximum speed shown under § 23.251, or the structural limitations; or

(3) Buffeting that would impair the pilot's ability to read the instruments or to control the airplane for recovery.

(c) There may be no control reversal about any axis at any speed up to the maximum speed shown under § 23.251. Any reversal of elevator control force or tendency of the airplane to pitch, roll, or yaw must be mild and readily controllable, using normal piloting techniques.

(Amdt. 23–7, Eff. 9/14/69); (Amdt. 23–26, Eff. 10/14/80); [(Amdt. 23–45, Eff. 9/7/93)]

(b) Unless otherwise provided, the air, ground, and water loads must be placed in equilibrium with inertia forces, considering each item of mass in the airplane. These loads must be distributed to conservatively approximate or closely represent actual conditions. Methods used to determine load intensities and distribution on canard and tandem wing configurations must be validated by flight test measurement unless the methods used for determining those loading conditions are shown to be reliable or conservative on the configuration under consideration.

(c) If deflections under load would significantly change the distribution of external or internal loads, this redistribution must be taken into account.

(d) Simplified structural design criteria may be used if they result in design loads not less than those prescribed in §§ 23.331 through 23.521. For conventional, single-engine airplanes with design weights of 6,000 pounds or less, the design criteria of appendix A of this part are an approved equivalent of §§ 23.321 through 23.459. If appendix A is used, the entire appendix must be substituted for the corresponding sections of this part.

(Amdt. 23–28, Eff. 4/28/82); (Amdt. 23–42, Eff. 2/4/91)

23.302 Canard or tandem wing configurations.

The forward structure of a canard or tandem wing configuration must:

(a) Meet all requirements of subpart C and subpart D of this part applicable to a wing; and

(b) Meet all requirements applicable to the function performed by these surfaces.

not interfere with safe operation.

(b) [The structure must be able to support ultimate loads without failure for at least three seconds, except local failures or structural instabilities between limit and ultimate load are acceptable only if the structure can sustain the required ultimate load for at least three seconds. However, when proof of strength is shown by dynamic tests simulating actual load conditions, the three second limit does not apply.]

[(Amdt. 23–45, Eff. 9/7/93)]

§ 23.307 Proof of structure.

(a) Compliance with the strength and deformation requirements of § 23.305 must be shown for each critical load condition. Structural analysis may be used only if the structure conforms to those for which experience has shown this method to be reliable. In other cases, substantiating load tests must be made. Dynamic tests, including structural flight tests, are acceptable if the design load conditions have been simulated.

(b) Certain parts of the structure must be tested as specified in subpart D of this part.

FLIGHT LOADS

§ 23.321 General.

(a) Flight load factors represent the ratio of the aerodynamic force component (acting normal to the assumed longitudinal axis of the airplane) to the weight of the airplane. A positive flight load factor is one in which the aerodynamic force acts upward, with respect to the airplane.

§§ 23.1583 through 23.1589.

[(c) When significant, the effects of compressibility must be taken into account.]

[(Amdt. 23–45, Eff. 9/7/93)]

§ 23.331 Symmetrical flight conditions.

(a) The appropriate balancing horizontal tail load must be accounted for in a rational or conservative manner when determining the wing loads and linear inertia loads corresponding to any of the symmetrical flight conditions specified in §§ 23.333 through 23.341.

(b) The incremental horizontal tail loads due to maneuvering and gusts must be reacted by the angular inertia of the airplane in a rational or conservative manner.

(c) Mutual influence of the aerodynamic surfaces must be taken into account when determining flight loads.

(Amdt. 23–42, Eff. 2/4/91)

§ 23.333 Flight envelope.

(a) *General.* Compliance with the strength requirements of this subpart must be shown at any combination of airspeed and load factor on and within the boundaries of a flight envelope (similar to the one in paragraph (d) of this section) that represents the envelope of the flight loading conditions specified by the maneuvering and gust criteria of paragraphs (b) and (c) of this section respectively.

(b) *Maneuvering envelope.* Except where limited by maximum (static) lift coefficients, the airplane is assumed to be subjected to symmetrical maneuvers resulting in the following limit load factors:

(1) The airplane is assumed to be subjected to symmetrical vertical gusts in level flight. The resulting limit load factors must correspond to the conditions determined as follows:

(i) Positive (up) and negative (down) gusts of 50 f.p.s. at V_C must be considered at altitudes between sea level and 20,000 feet. The gust velocity may be reduced linearly from 50 f.p.s. at 20,000 feet to 25 f.p.s. at 50,000 feet.

(ii) Positive and negative gusts of 25 f.p.s. at V_D must be considered at altitudes between sea level and 20,000 feet. The gust velocity may be reduced linearly from 25 f.p.s. at 20,000 feet to 12.5 f.p.s. at 50,000 feet.

(iii) In addition, for commuter category airplanes, positive (up) and negative (down) rough air gusts of 66 f.p.s. at V_B must be considered at altitudes between sea level and 20,000 feet. The gust velocity may be reduced linearly from 66 f.p.s. at 20,000 feet to 38 f.p.s. at 50,000 feet.

(2) The following assumptions must be made:

(i) The shape of the gust is—

$$U=\frac{U_{de}}{2}\left(1-\cos\frac{2\pi s}{25C}\right)$$

where—

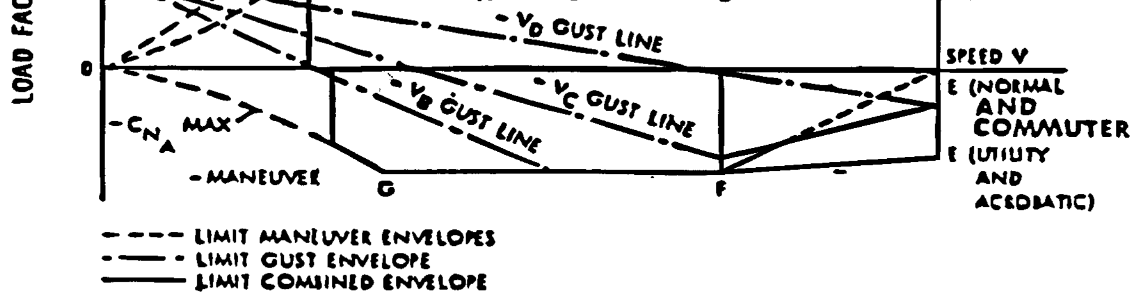
s=Distance penetrated into gust (ft.);

C=Mean geometric chord of wing (ft.); and

U_{de}=Derived gust velocity referred to in subparagraph (1) of this section.

(ii) Gust load factors vary linearly with speed between V_C and V_D.

(d) *Flight envelope.*



NOTE: Point G need not be investigated when the supplementary condition specified in § 23.369 is investigated.

(Amdt. 23–7, Eff. 9/14/69); (Amdt. 23–34, Eff. 2/17/87)

§ 23.335 Design airspeeds.

Except as provided in paragraph (a)(4) of this section, the selected design airspeeds are equivalent airspeeds (EAS).

(a) *Design cruising speed, V_C*. For V_C the following apply:

(1) V_C (in knots) may not be less than—

(i) $33\sqrt{W/S}$ (for normal, utility, and commuter category airplanes); and

(ii) $36\sqrt{W/S}$ (For acrobatic category airplanes).

(2) For values of W/S more than 20, the multiplying factors may be decreased linearly with W/S to a value of 28.6 where W/S=100.

(3) V_C need not be more than 0.9 V_H at sea level.

(4) At altitudes where an M_D is established, a cruising speed M_C limited by compressibility may be selected.

(b) *Design dive speed V_D*. For V_D, the following apply:

(1) V_D/M_D may not be less than 1.25 V_C/M_C; and

(2) With $V_{C\ min}$, the required minimum design cruising speed, V_D (in knots) may not be less than—

(i) 1.40 $V_{C\ min}$ (for normal and commuter category airplanes);

(ii) 1.50 $V_{C\ min}$ (for utility category airplanes); and

(iii) 1.55 $V_{C\ min}$ (for acrobatic category airplanes).

(3) For values of W/S more than 20, the multiplying factors in paragraph (b)(2) of this section may be decreased linearly with W/S to a value of 1.35 where W/S=100.

(4) Compliance with paragraphs (b)(1) and (2) of this section need not be shown if V_D/M_D is selected so that the minimum speed margin between V_C/M_C and V_D/M_D is the greater of the following:

(i) The speed increase resulting when, from the initial condition of stabilized flight at V_C/M_C, the airplane is assumed to be upset, flown for 20 seconds along a flight path 7.5° below the initial path, and then pulled up with a load factor of 1.5 (0.5g acceleration increment). At least 75 percent maximum continuous power for reciprocating engines, and maximum cruising power for turbines, or, if less, the power required for V_C/M_C for both kinds of engines, must be assumed until the pullup is initiated, at which point power reduction and pilot-controlled drag devices may be used.

(ii) Mach 0.05 (at altitudes where an M_D is established).

(c) *Design maneuvering speed V_A*. For V_A, the following applies:

(1) V_A may not be less than $V_S\sqrt{n}$ where—

For V_B, the following apply:

(1) V_B may not be less than the speed determined by the intersection of the line representing the maximum positive lift $C_{N\ max}$ and the line representing the rough air gust velocity on the gust V–n diagram, or $\sqrt{(N_g)}\ V_{S1}$, whichever is less, where:

(i) n_g the positive airplane gust load factor due to gust, at speed V_C (in accordance with § 23.341), and at the particular weight under consideration; and

(ii) V_{S1} is the stalling speed with the flaps retracted at the particular weight under consideration.

(2) V_B need not be greater than V_C.

(Amdt. 23–7, Eff. 9/14/69); (Amdt. 23–16, Eff. 2/14/75); (Amdt. 23–34, Eff. 2/17/87)

§ 23.337 Limit maneuvering load factors.

(a) The positive limit maneuvering load factor n may not be less than—

(1) $2.1 + [24{,}000/(W + 10{,}000)]$ for normal and commuter category airplanes, except that n need not be more than 3.8;

(2) 4.4 for utility category airplanes; or

(3) 6.0 for acrobatic category airplanes.

(b) The negative limit maneuvering load factor may not be less than—

(1) 0.4 times the positive load factor for the normal, utility, and commuter categories; or

(2) 0.5 times the positive load factor for the acrobatic category.

(c) Maneuvering load factors lower than those specified in this section may be used if the airplane has design features that make it impossible to exceed these values in flight.

(Amdt. 23–7, Eff. 9/14/69); (Amdt. 23–34, Eff. 2/17/87)

§ 23.341 Gust load factors.

(a) The gust load for a canard or tandem wing configuration must be computed using a rational analysis, considering the criteria of § 23.333(c), to

498(W/S)

where—

$$K_g = \frac{0.88\ \mu_g}{5.3+\mu_g} = \text{gust alleviation factor;}$$

$$\mu_g = \frac{2(w/s)}{\rho C a g} = \text{airplane mass ratio;}$$

U_{de} = Derived gust velocities referred to in § 23.333(c) (f.p.s.);
ρ = Density of air (slugs/cu. ft.);
W/S = Wing loading (p.s.f.);
C = Mean geometric chord (ft.);
g = Acceleration due to gravity (ft/sec.^{2});
V = Airplane equivalent speed (knots); and
a = Slope of the airplane normal force coefficient curve C_{NA} per radian if the gust loads are applied to the wings and horizontal tail surfaces simultaneously by a rational method. The wing lift curve slope C_L per radian may be used when the gust load is applied to the wings only and the horizontal tail gust loads are treated as a separate condition.

(Amdt. 23–7, Eff. 9/14/69); (Amdt. 23–42, Eff. 2/4/91)

§ 23.345 High lift devices.

(a) If flaps or similar high lift devices to be used for takeoff, approach, or landing are installed, the airplane, with the flaps fully deflected at V_F, is assumed to be subjected to symmetrical maneuvers and gusts resulting in limit load factors within the range determined by—

(1) Maneuvering, to a positive limit load factor of 2.0; and

(2) Positive and negative gust of 25 feet per second acting normal to the flight path in level flight.

(b) V_F must be assumed to be not less than $1.4\ V_S$ or $1.8\ V_{SF}$, whichever is greater,

where—

V_S is the computed stalling speed with flaps retracted at the design weight; and

V_{SF} is the computed stalling speed with flaps fully extended at the design weight.

§ 23.457(b).

(d) In determining external loads on the airplane as a whole, thrust, slipstream, and pitching acceleration may be assumed to be zero.

(e) The requirements of § 23.457, and this section may be complied with separately or in combination.

(Amdt. 23–7, Eff. 9/14/69); (Amdt. 23–23, Eff. 12/1/78)

§ 23.347 Unsymmetrical flight conditions.

The airplane is assumed to be subjected to the unsymmetrical flight conditions of §§ 23.349 and 23.351. Unbalanced aerodynamic moments about the center of gravity must be reacted in a rational or conservative manner, considering the principal masses furnishing the reacting inertia forces.

§ 23.349 Rolling conditions.

The wing and wing bracing must be designed for the following loading conditions:

(a) Unsymmetrical wing loads appropriate to the category. Unless the following values result in unrealistic loads, the rolling accelerations may be obtained by modifying the symmetrical flight conditions in § 23.333(d) as follows:

(1) For the acrobatic category, in conditions A and F, assume that 100 percent of the semispan wing airload acts on one side of the plane of symmetry and 60 percent of this load acts on the other side.

(2) For the normal, utility, and commuter categories, in condition A, assume that 100 percent of the semispan wing airload acts on one side of the airplane, and 70 percent of this load acts on the other side. For airplanes of more than 1,000 pounds design weight, the latter percentage may be increased linearly with weight up through 75 percent at 12,500 pounds to the maximum gross weight of the airplane.

(b) The loads resulting from the aileron deflections and speeds specified in § 23.455, in combination with an airplane load factor of at least two thirds of the positive maneuvering load factor used for design. Unless the following values result in

δ is the down aileron deflection in degrees in the critical condition.

(Amdt. 23–7, Eff. 9/14/69); (Amdt. 23–34, Eff. 2/17/87)

§ 23.351 Yawing conditions.

The airplane must be designed for yawing loads on the vertical surfaces resulting from the loads specified in §§ 23.441 through 23.445.

(Amdt. 23–42, Eff. 2/4/91)

§ 23.361 Engine torque.

(a) Each engine mount and its supporting structure must be designed for the effects of—

(1) A limit engine torque corresponding to takeoff power and propeller speed acting simultaneously with 75 percent of the limit loads from flight condition A of § 23.333(d);

(2) [A limit engine torque corresponding to maximum continuous power and propeller speed acting simultaneously with the limit loads from flight condition A of § 23.333(d); and]

(3) For turbopropeller installations, in addition to the conditions specified in paragraphs (a)(1) and (a)(2) of this section, a limit engine torque corresponding to takeoff power and propeller speed, multiplied by a factor accounting for propeller control system malfunction, including quick feathering, acting simultaneously with 1g level flight loads. In the absence of a rational analysis, a factor of 1.6 must be used.

(b) For turbine engine installations, the engine mounts and supporting structure must be designed to withstand each of the following:

(1) A limit engine torque load imposed by sudden engine stoppage due to malfunction or structural failure (such as compressor jamming).

(2) A limit engine torque load imposed by the maximum acceleration of the engine.

(c) [The limit engine torque to be considered under paragraph (a) of this section must be obtained by multiplying the mean torque by a factor of—]

(1) 1.25 for turbopropeller installations;

(a) Each engine mount and its supporting structure must be designed for a limit load factor in a lateral direction, for the side load on the engine mount, of not less than—

(1) 1.33; or

(2) One-third of the limit load factor for flight condition A.

(b) The side load prescribed in paragraph (a) of this section may be assumed to be independent of other flight conditions.

§ 23.365 Pressurized cabin loads.

For each pressurized compartment, the following apply:

(a) The airplane structure must be strong enough to withstand the flight loads combined with pressure differential loads from zero up to the maximum relief valve setting.

(b) The external pressure distribution in flight, and any stress concentrations, must be accounted for.

(c) If landings may be made with the cabin pressurized, landing loads must be combined with pressure differential loads from zero up to the maximum allowed during landing.

(d) The airplane structure must be strong enough to withstand the pressure differential loads corresponding to the maximum relief valve setting multiplied by a factor of 1.33, omitting other loads.

(e) If a pressurized cabin has two or more compartments separated by bulkheads or a floor, the primary structure must be designed for the effects of sudden release of pressure in any compartment with external doors or windows. This condition must be investigated for the effects of failure of the largest opening in the compartment. The effects of intercompartmental venting may be considered.

§ 23.367 Unsymmetrical loads due to engine failure.

(a) Turbopropeller airplanes must be designed for the unsymmetrical loads resulting from the failure of the critical engine including the following condi-

compressor from the turbine or from loss of the turbine blades are considered to be ultimate loads.

(3) The time history of the thrust decay and drag buildup occurring as a result of the prescribed engine failures must be substantiated by test or other data applicable to the particular engine-propeller combination.

(4) The timing and magnitude of the probable pilot corrective action must be conservatively estimated, considering the characteristics of the particular engine-propeller-airplane combination.

(b) Pilot corrective action may be assumed to be initiated at the time maximum yawing velocity is reached, but not earlier than 2 seconds after the engine failure. The magnitude of the corrective action may be based on the limit pilot forces specified in § 23.397 except that lower forces may be assumed where it is shown by analysis or test that these forces can control the yaw and roll resulting from the prescribed engine failure conditions.

(Amdt. 23–7, Eff. 9/14/69)

§ 23.369 [Rear lift truss.]

(a) If a rear lift truss is used, it must be designed for conditions of reversed airflow at a design speed of—

$$V = 8.7\sqrt{W/S} + 8.7 \text{ (knots)}$$

(b) Either aerodynamic data for the particular wing section used, or a value of C_L equalling –0.8 with a chordwise distribution that is triangular between a peak at the trailing edge and zero at the leading edge, must be used.

(Amdt. 23–7, Eff. 9/14/69); [(Amdt. 23–45, Eff. 9/7/93)]

§ 23.371 [Gyroscopic and aerodynamic loads.

[For turbine-powered airplanes, each engine mount and its supporting structure must be designed for the combined gyroscopic and aerodynamic loads that result, with the engines at maximum continuous r.p.m., under either of the following conditions:]

14/80); [(Amdt. 23–45, Eff. 9/7/93)]

§ 23.373 Speed control devices.

If speed control devices (such as spoilers and drag flaps) are incorporated for use in enroute conditions—

(a) The airplane must be designed for the symmetrical maneuvers and gusts prescribed in §§ 23.333, 23.337, and 23.341, and the yawing maneuvers and lateral gusts in §§ 23.441 and 23.443, with the device extended at speeds up to the placard device extended speed; and

(b) If the device has automatic operating or load limiting features, the airplane must be designed for the maneuver and gust conditions prescribed in paragraph (a) of this section at the speeds and corresponding device positions that the mechanism allows.

(Amdt. 23–7, Eff. 9/14/69)

CONTROL SURFACE AND SYSTEM LOADS

§ 23.391 Control surface loads.

(a) The control surface loads specified in §§ 23.397 through 23.459 are assumed to occur in the conditions described in §§ 23.331 through 23.351.

(b) If allowed by the following sections, the values of control surface loading in appendix B of this part may be used, instead of particular control surface data, to determine the detailed rational requirements of §§ 23.397 through 23.459, unless these values result in unrealistic loads.

§ 23.395 Control system loads.

(a) Each flight control system and its supporting structure must be designed for loads corresponding to at least 125 percent of the computed hinge moments of the movable control surface in the

the pilot and the autopilot act in opposition, the part of the system between them may be designed for the maximum effort of the one that imposes the lesser load. Pilot forces used for design need not exceed the maximum forces prescribed in § 23.397(b).

(2) The design must, in any case, provide a rugged system for service use, considering jamming, ground gusts, taxiing downwind, control inertia, and friction. Compliance with this subparagraph may be shown by designing for loads resulting from application of the minimum forces prescribed in § 23.397(b).

(b) A 125 percent factor on computed hinge moments must be used to design elevator, aileron, and rudder systems. However, a factor as low as 1.0 may be used if hinge moments are based on accurate flight test data, the exact reduction depending upon the accuracy and reliability of the data.

(c) Pilot forces used for design are assumed to act at the appropriate control grips or pads as they would in flight, and to react at the attachments of the control system to the control surface horns.

(Amdt. 23–7, Eff. 9/14/69); (Amdt. 23–34, Eff. 2/17/87)

§ 23.397 Limit control forces and torques.

(a) In the control surface flight loading condition, the airloads on movable surfaces and the corresponding deflections need not exceed those that would result in flight from the application of any pilot force within the ranges specified in paragraph (b) of this section. In applying this criterion, the effects of control system boost and servo-mechanisms, and the effects of tabs must be considered. The automatic pilot effort must be used for design if it alone can produce higher control surface loads than the human pilot.

(b) The limit pilot forces and torques are as follows:

Elevator:		
Stick	167 lbs.	100 lbs.
Wheel (symmetrical)	200 lbs.	100 lbs.
Wheel (unsymmetrical)[5]		100 lbs.
Rudder	200 lbs.	[150] lbs.

[1] For design weight (W) more than 5,000 pounds, the specified maximum values must be increased linearly with weight to 1.18 times the specified values at a design weight of 12,500 pounds, and for commuter category airplanes, the specified values must be increased linearly with weight to 1.35 times the specified values at a design weight of 19,000 pounds.

[2] If the design of any individual set of control systems or surfaces makes these specified minimum forces or torques inapplicable, values corresponding to the present hinge moments obtained under § 23.415, but not less than 0.6 of the specified minimum forces or torques, may be used.

[3] The critical parts of the aileron control system must also be designed for a single tangential force with a limit value of 1.25 times the couple force determined from the above criteria.

[4] D = wheel diameter (inches).

[5] The unsymmetrical force must be applied at one of the normal handgrip points on the control wheel.

(Amdt. 23–7, Eff. 9/14/69); (Amdt. 23–17, Eff. 2/1/77); (Amdt. 23–34, Eff. 2/17/87); [(Amdt. 23–45, Eff. 9/7/93)]

§ 23.399 Dual control system.

Each dual control system must be designed for the pilots operating in opposition, using individual pilot forces not less than—

(a) 0.75 times those obtained under § 23.395; or

(b) The minimum forces specified in § 23.397(b).

§ 23.405 Secondary control system.

Secondary controls, such as wheel brakes, spoilers, and tab controls, must be designed for the maximum forces that a pilot is likely to apply to those controls.

§ 23.407 Trim tab effects.

The effects of trim tabs on the control surface design conditions must be accounted for only where the surface loads are limited by maximum pilot effort. In these cases, the tabs are considered to be deflected in the direction that would assist the pilot. These deflections must correspond to the

§ 23.415 Ground gust conditions.

(a) The control system must be investigated as follows for control surface loads due to ground gusts and taxiing downwind:

(1) If an investigation of the control system for ground gust loads is not required by subparagraph (2) of this paragraph, but the applicant elects to design a part of the control system for these loads, these loads need only be carried from control surface horns through the nearest stops or gust locks and their supporting structures.

(2) If pilot forces less than the minimums specified in § 23.397(b) are used for design, the effects of surface loads due to ground gusts and taxiing downwind must be investigated for the entire control system according to the formula:

$$H = KcSq$$

where—

H = limit hinge moment (ft.-lbs.);

c = mean chord of the control surface aft of the hinge line (ft.);

S = area of control surface aft of the hinge line (sq. ft.);

q = dynamic pressure (p.s.f) based on a design speed not less than $14.6\sqrt{W/S} + 14.6$ (f.p.s.) except that the design speed need not exceed 88 (f.p.s.); and

K = limit hinge moment factor for ground gusts derived in paragraph (b) of this section. (For ailerons and elevators, a positive value of K indicates a moment tending to depress the surface and a negative value of K indicates a moment tending to raise the surface).

(b) The limit hinge moment factor K for ground gusts must be derived as follows:

Surface	K	Position of controls
(a) Aileron	0.75	Control column locked or lashed in mid-position.
(b) Aileron	±0.50	Ailerons at full throw; + moment on one aileron, – moment on the other.
(c) Elevator	±0.75	(c) Elevator full up (–).
(d) Elevator		(d) Elevator full down (+).
(e) Rudder	±0.75	(e) Rudder in neutral.
(f) Rudder		(f) Rudder at full throw.

HORIZONTAL STABILIZING AND BALANCING SURFACES

§ 23.421 Balancing loads.

(a) A horizontal surface balancing load is a load necessary to maintain equilibrium in any specified flight condition with no pitching acceleration.

(b) Horizontal balancing surfaces must be designed for the balancing loads occurring at any point on the limit maneuvering envelope and in the flap conditions specified in § 23.345.

(Amdt. 23–7, Eff. 9/14/69); (Amdt. 23–42, Eff. 2/4/91)

§ 23.423 Maneuvering loads.

Each horizontal surface and its supporting structure, and the main wing of a canard or tandem wing configuration, if that surface has pitch control, must be designed for the maneuvering loads imposed by the following conditions:

(a) A sudden movement of the pitching control, at the speed V_A, to the maximum aft movement, and the maximum forward movement, as limited by the control stops, or pilot effort, whichever is critical.

(b) A sudden aft movement of the pitching control at speeds above V_A, followed by a forward movement of the pitching control resulting in the following combinations of normal and angular acceleration:

Condition	Normal acceleration (n)	Angular acceleration (radian/sec$_2$)
Nose-up pitching.	1.0	$+39n_m/V \times (n_m - 1.5)$
Nose-down pitching.	n_m	$-39n_m/V \times (n_m - 1.5)$

where—

n_m = positive limit maneuvering load factor used in the design of the airplane; and

V = initial speed in knots.

The conditions in this paragraph involve loads corresponding to the loads that may occur in a "checked maneuver" (a maneuver in which the pitching control is suddenly displaced in one direction and then suddenly moved in the opposite direction). The deflections and timing of the "checked maneuver" must avoid exceeding the limit maneuvering load factor. The total horizontal surface load for both nose-up and nose-down pitching conditions is the sum of the balancing loads at V and the specified value of the normal load factor n, plus the manuevering load increment due to the specified value of the angular acceleration.

(Amdt. 23–7, Eff. 9/14/69); (Amdt. 23–42, Eff. 2/4/91)

§ 23.425 Gust loads.

(a) Each horizontal surface, other than a main wing, must be designed for loads resulting from—

(1) Gust velocities specified in § 23.333(c) with flaps retracted; and

(2) Positive and negative gusts of 25 f.p.s. nominal intensity at V_F corresponding to the flight conditions specified in § 23.345(a)(2).

(b) Reserved

(c) When determining the total load on the horizontal surfaces for the conditions specified in paragraph (a) of this section, the initial balancing loads for-steady unaccelerated flight at the pertinent design speeds V_F, V_C, and V_D must first be determined. The incremental load resulting from the gusts must be added to the initial balancing load to obtain the total load.

(d) In the absence of a more rational analysis, the incremental load due to the gust must be computed as follows only on airplane configurations with aft-mounted, horizontal surfaces, unless its use elsewhere is shown to be conservative:

$$\Delta L_{ht} = \frac{K_g U_{de} V a_{ht} S_{ht}}{498}\left(1-\frac{d\varepsilon}{d\alpha}\right)$$

where—

ΔL_{ht} = Incremental horizontal tail load (lbs.);

K_g = Gust alleviation factor defined in § 23.341;

U_{de} = Derived gust velocity (f.p.s.);

V = Airplane equivalent speed (knots);

a_{ht} = Slope of aft horizontal tail lift curve (per radian);

S_{ht} = Area of aft horizontal lift surface (ft^2); and

$\left(1-\frac{d\varepsilon}{d\alpha}\right)$ = Downwash factor.

(Amdt. 23–7, Eff. 9/14/69); (Amdt. 23–42, Eff. 2/4/91) of engines, wings, horizontal surfaces other than main wing, and fuselage shape:

(1) 100 percent of the maximum loading from the symmetrical flight conditions may be assumed on the surface on one side of the plane of symmetry; and

(2) The following percentage of that loading must be applied to the opposite side:

Percent = 100−10 (n–1), where n is the specified positive maneuvering load factor, but this value may not be more than 80 percent.

(c) For airplanes that are not conventional (such as airplanes with horizontal surfaces other than main wing having appreciable dihedral or supported by the vertical tail surfaces) the surfaces and supporting structures must be designed for combined vertical and horizontal surface loads resulting from each prescribed flight condition taken separately.

(Amdt. 23–14, Eff. 12/20/73); (Amdt. 23–42, Eff. 2/4/91)

VERTICAL SURFACES

§ 23.441 Maneuvering loads.

(a) At speeds up to V_A, the vertical surfaces must be designed to withstand the following conditions. In computing the loads, the yawing velocity may be assumed to be zero:

(1) With the airplane in unaccelerated flight at zero yaw, it is assumed that the rudder control is suddenly displaced to the maximum deflection, as limited by the control stops or by limit pilot forces.

(2) With the rudder deflected as specified in paragraph (a)(1) of this section, it is assumed that the airplane yaws to the resulting sideslip angle. In lieu of a rational analysis, an overswing angle equal to 1.3 times the static sideslip angle of paragraph (a)(3) of this section may be assumed.

(2) Uncoordinated rolls from steep banks; or

(3) Sudden failure of the critical engine with delayed corrective action.

(Amdt. 23–7, Eff. 9/14/69); (Amdt. 23–14, Eff. 12/20/73); (Amdt. 23–28, Eff. 4/28/82); (Amdt. 23–42, Eff. 2/4/91)

§ 23.443 Gust loads.

(a) Vertical surfaces must be designed to withstand, in unaccelerated flight at speed V_C, lateral gusts of the values prescribed for V_C in § 23.333(c).

(b) In addition, for commuter category airplanes, the airplane is assumed to encounter derived gusts normal to the plane of symmetry while in unaccelerated flight at V_B, V_C, V_D, and V_F. The derived gusts and airplane speeds corresponding to these conditions, as determined by §§ 23.341 and 23.345, must be investigated. The shape of the gust must be as specified in § 23.333(c)(2)(i).

(c) In the absence of a more rational analysis, the gust load must be computed as follows:

$$L_{vt} = \frac{K_{gt}\, U_{de}\, Va_{vt}\, S_{vt}}{498}$$

where—

L_{vt} = Vertical surface loads (lbs.);

$K_{gt} = \dfrac{0.88\ \mu gt}{5.3 + \mu gt}$ = gust alleviation factor;

$\mu gt = \dfrac{2W}{\rho C_t g a_{vt} S_{vt}} \left(\dfrac{K}{1_t} \right)^2$ = Lateral mass ratio;

U_{de} = Derived gust velocity (f.p.s);

ρ = Air density (slugs/cu ft.);

W = Airplane weight (lbs.);

S_{vt} = Area of vertical surface (ft.^{2});

C_t = Mean geometric chord of vertical surface (ft.);

a_{vt} = Lift curve slope of vertical surface (per radian);

K = Radius of gyration in yaw (ft.);

1_t = Distance from airplane c.g. to lift center of vertical surface (ft.);

g = Acceleration due to gravity (ft./sec.^{2}) ; and load in combination with loads induced by the fins or winglets and moments or forces exerted on the horizontal surfaces or wings by the fins or winglets.

(b) If outboard fins or winglets extend above and below the horizontal surface, the critical vertical surface loading (the load per unit area as determined under §§ 23.441 and 23.443) must be applied to—

(1) The part of the vertical surfaces above the horizontal surface with 80 percent of that loading applied to the part below the horizontal surface; and

(2) The part of the vertical surfaces below the horizontal surface with 80 percent of that loading applied to the part below the horizontal surface;

(c) The end plate effects of outboard fins or winglets must be taken into account in applying the yawing conditions of § 23.441 and § 23.443 to the vertical surfaces in paragraph (b) of this section.

(d) When rational methods are used for computing loads, the maneuvering loads of § 23.441 on the vertical surfaces and the 1.0g horizontal surface load, including induced loads on the horizontal surface and moments or forces exerted on the horizontal surfaces by the vertical surfaces, must be applied simultaneously for the structural loading condition.

(Amdt. 23–14, Eff. 12/20/73); (Amdt. 23–42, Eff. 2/4/91)

AILERONS, WING FLAPS, AND SPECIAL DEVICES

§ 23.455 Ailerons.

(a) The ailerons must be designed for the loads to which they are subjected—

(1) In the neutral position during symmetrical flight conditions; and

(2) By the following deflections (except as limited by pilot effort), during unsymmetrical flight conditions; and

obtained in paragraph (a)(2)(i) of this section.

(b) [Reserved]

(Amdt. 23–7, Eff. 9/14/69); (Amdt. 23–42, Eff. 2/4/91)

§ 23.457 Wing flaps.

(a) The wing flaps, their operating mechanisms, and their supporting structures must be designed for critical loads occurring in the flaps-extended flight conditions with the flaps in any position. However, if an automatic flap load limiting device is used, these components may be designed for the critical combinations of airspeed and flap position allowed by that device.

(b) The effects of propeller slipstream, corresponding to takeoff power, must be taken into account at not less than 1.4 V_S, where V_S is the computed stalling speed with flaps fully retracted at the design weight. For the investigation of slipstream effects, the load factor may be assumed to be 1.0.

§ 23.459 Special devices.

The loading for special devices using aerodynamic surfaces (such as slots and spoilers) must be determined from test data.

GROUND LOADS

§ 23.471 General.

The limit ground loads specified in this subpart are considered to be external loads and inertia forces that act upon an airplane structure. In each specified ground load condition, the external reactions must be placed in equilibrium with the linear and angular inertia forces in a rational or conservative manner.

§ 23.473 Ground load conditions and assumptions.

(a) The ground load requirements of this subpart must be complied with at the design maximum weight except that §§ 23.479, 23.481, and 23.483

ous power plus a capacity equal to a fuel weight which is the difference between the design maximum weight and the design landing weight; or

(2) The design maximum weight less the weight of 25 percent of the total fuel capacity.

(c) The design landing weight of a multiengine airplane may be less than that allowed under paragraph (b) of this section if—

(1) The airplane meets the one-engine-inoperative climb requirements of § 23.67(a) or (b)(1); and

(2) Compliance is shown with the fuel jettisoning system requirements of § 23.1001.

(d) The selected limit vertical inertia load factor at the center of gravity of the airplane for the ground load conditions prescribed in this subpart may not be less than that which would be obtained when landing with a descent velocity (V), in feet per second, equal to 4.4 $(W/S)^{1/4}$ except that this velocity need not be more than 10 feet per second and may not be less than seven feet per second.

(e) Wing lift not exceeding two-thirds of the weight of the airplane may be assumed to exist throughout the landing impact and to act through the center of gravity. The ground reaction load factor may be equal to the inertia load factor minus the ratio of the above assumed wing lift to the airplane weight.

(f) [Energy absorption tests (to determine the limit load factor corresponding to the required limit descent velocities) must be made under § 23.723(a) unless specifically exempted by that section.]

(g) No inertia load factor used for design purposes may be less than 2.67, nor may the limit ground reaction load factor be less than 2.0 at design maximum weight, unless these lower values will not be exceeded in taxiing at speeds up to takeoff speed over terrain as rough as that expected in service.

(Amdt. 23–7, Eff. 9/14/69); (Amdt. 23–28, Eff. 4/28/82); [(Amdt. 23–45, Eff. 9/7/93)]

to be in the following attitudes:

(1) For airplanes with tail wheels, a normal level flight attitude.

(2) For airplanes with nose wheels, attitudes in which—

(i) The nose and main wheels contact the ground simultaneously; and

(ii) The main wheels contact the ground and the nose wheel is just clear of the ground.

The attitude used in paragraph (a)(2)(i) of this section may be used in the analysis required under paragraph (a)(2)(ii) of this section.

(b) [When investigating landing conditions, the drag components simulating the forces required to accelerate the tires and wheels up to the landing speed (spin-up) must be properly combined with the corresponding instantaneous vertical ground reactions, and the forward-acting horizontal loads resulting from rapid reduction of the spin-up drag loads (spring-back) must be combined with vertical ground reactions at the instant of the peak forward load, assuming wing lift and a tire-sliding coefficient of friction of 0.8. However, the drag loads may not be less than 25 percent of the maximum vertical ground reactions (neglecting wing lift).

(c) [In the absence of specific tests or a more rational analysis for determining the wheel spin-up and spring-back loads for landing conditions, the method set forth in appendix D of this part must be used. If appendix D of this part is used, the drag components used for design must not be less than those given by appendix C of this part.]

(d) For airplanes with tip tanks or large overhung masses (such as turbo-propeller or jet engines) supported by the wing, the tip tanks and the structure supporting the tanks or overhung masses must be designed for the effects of dynamic responses under the level landing conditions of either paragraph (a)(1) or (a)(2)(ii) of this section. In evaluating the effects of dynamic, response, an airplane lift equal to the weight of the airplane may be assumed.

(Amdt. 23–17, Eff. 2/1/77); [(Amdt. 23–45, Eff. 9/7/93)] clearance by each part of the airplane, whichever is less.

(b) For airplanes with either tail or nose wheels, ground reactions are assumed to be vertical, with the wheels up to speed before the maximum vertical load is attained.

§ 23.483 One-wheel landing conditions.

For the one-wheel landing condition, the airplane is assumed to be in the level attitude and to contact the ground on one side of the main landing gear. In this attitude, the ground reactions must be the same as those obtained on that side under § 23.479.

§ 23.485 Side load conditions.

(a) For the side load condition, the airplane is assumed to be in a level attitude with only the main wheels contacting the ground and with the shock absorbers and tires in their static positions.

(b) The limit vertical load factor must be 1.33, with the vertical ground reaction divided equally between the main wheels.

(c) The limit side inertia factor must be 0.83, with the side ground reaction divided between the main wheels so that—

(1) 0.5 (*W*) is acting inboard on one side; and

(2) 0.33 (*W*) is acting outboard on the other side.

[(d) The side loads prescribed in paragraph (c) of this section are assumed to be applied at the ground contact point and the drag loads may be assumed to be zero.]

[(Amdt. 23–45, Eff. 9/7/93)]

§ 23.493 Braked roll conditions.

Under braked roll conditions, with the shock absorbers and tires in their static positions, the following apply:

(a) The limit vertical load factor must be 1.33.

(b) The attitudes and ground contacts must be those described in § 23.479 for level landings.

(c) A drag reaction equal to the vertical reaction at the wheel multiplied by a coefficient of friction

and affected supporting structures, the following apply:

(a) For the obstruction load, the limit ground reaction obtained in the tail down landing condition is assumed to act up and aft through the axle at 45°, The shock absorber and tire may be assumed to be in their static positions.

(b) For the side load, a limit vertical ground reaction equal to the static load on the tail wheel, in combination with a side component of equal magnitude, is assumed. In addition—

(1) If a swivel is used, the tail wheel is assumed to be swiveled 90° to the airplane longitudinal axis with the resultant ground load passing through the axle;

(2) If a lock, steering device, or shimmy damper is used, the tail wheel is also assumed to be in the trailing position with the side load acting at the ground contact point; and

(3) The shock absorber and tire are assumed to be in their static positions.

§ 23.499 Supplementary conditions for nose wheels.

In determining the ground loads on nose wheels and affected supporting structures, and assuming that the shock absorbers and tires are in their static positions, the following conditions must be met:

(a) For aft loads, the limit force components at the axle must be—

(1) A vertical component of 2.25 times the static load on the wheel; and

(2) A drag component of 0.8 times the vertical load.

(b) For forward loads, the limit force components at the axle must be—

(1) A vertical component of 2.25 times the static load on the wheel; and

(2) A forward component of 0.4 times the vertical load.

(c) For side loads, the limit force components at ground contact must be—

(1) A vertical component of 2.25 times the static load on the wheel; and

near the tail assembly, with a factor of safety of 1.

(Amdt. 23–7, Eff. 9/14/69)

§ 23.507 Jacking loads.

(a) The airplane must be designed for the loads developed when the aircraft is supported on jacks at the design maximum weight assuming the following load factors for landing gear jacking points at a three-point attitude and for primary flight structure jacking points in the level attitude:

(1) Vertical-load factor of 1.35 times the static reactions.

(2) Fore, aft, and lateral load factors of 0.4 times the vertical static reactions.

(b) The horizontal loads at the jack points must be reacted by inertia forces so as to result in no change in the direction of the resultant loads at the jack points.

(c) The horizontal loads must be considered in all combinations with the vertical load.

(Amdt. 23–14, Eff. 12/20/73)

§ 23.509 Towing loads.

The towing loads of this section must be applied to the design of tow fittings and their immediate attaching structure.

(b) For towing points not on the landing gear but near the plane of symmetry of the airplane, the drag and side tow load components specified for the auxiliary gear apply. For towing points located outboard of the main gear, the drag and side tow load components specified for the main gear apply. Where the specified angle of swivel cannot be reached, the maximum obtainable angle must be used.

(c) The towing loads specified in paragraph (d) of this section must be reacted as follows:

(1) The side component of the towing load at the main gear must be reacted by a side force at the static ground line of the wheel to which the load is applied.

(2) The towing loads at the auxiliary gear and the drag components of the towing loads at the main gear must be reacted as follows:

(i) A reaction with a maximum value equal to the vertical reaction must be applied at the axle of the wheel to which the load is applied. Enough airplane inertia to achieve equilibrium must be applied.

(ii) The loads must be reacted by airplane inertia.

(d) The prescribed towing loads are as follows, where *W* is the design maximum weight:

Tow point	Position	Load		
		Magnitude	No.	Direction
Main Gear		0.225W	1	Forward, parallel to drag axis.
			2	Forward, at 30° to drag axis.
			3	Aft, parallel to drag axis.
			4	Aft, at 30° to drag axis.
Auxiliary gear	Swiveled forward	0.3W	5	Forward.
			6	Aft.
	Swiveled aft	0.3W	7	Forward.
			8	Aft.
	Swiveled 45° from forward	0.15W	9	Forward, in plane of wheel.
			10	Aft, in plane of wheel.
	Swiveled 45° from aft	0.15W	11	Forward, in plane of wheel.
			12	Aft, in plane of wheel.

(2) Loads corresponding to a limit vertical load factor of 1, and coefficient of friction of 0.8 applied to the main gear and its supporting structure.

(b) *Unequal tire loads.* The loads established under §§ 23.471 through 23.483 must be applied in turn, in a 60/40 percent distribution, to the dual wheels and tires in each dual wheel landing gear unit.

(c) *Deflated tire loads.* For the deflated tire condition—

(1) 60 percent of the loads established under §§ 23.471 through 23.483 must be applied in turn to each wheel in a landing gear unit; and

(2) 60 percent of the limit drag and side loads, and 100 percent of the limit vertical load established under §§ 23.485 and 23.493 or lesser vertical load obtained under paragraph (c)(1) of this section, must be applied in turn to each wheel in the dual wheel landing gear unit.

(Amdt. 23–7, Eff. 9/14/69)

WATER LOADS

§ 23.521 Water load conditions.

(a) The structure of seaplanes and amphibians must be designed for water loads developed during takeoff and landing with the seaplane in any attitude likely to occur in normal operation at appropriate forward and sinking velocities under the most severe sea conditions likely to be encountered.

(b) [Unless the applicant makes a rational analysis of the water loads, §§ 23.523 through 23.537 apply.

(c) [Floats previously approved by the FAA may be installed on airplanes that are certificated under this part, provided that the floats meet the criteria of paragraph (a) of this section.]

[(Amdt. 23–45, Eff. 9/7/93)]

ters of gravity within the limits for which certification is requested must be considered to reach maximum design loads for each part of the seaplane structure.]

[(Amdt. 23–45, Eff. 9/7/93)]

[§ 23.525 Application of loads.

[(a) Unless otherwise prescribed, the seaplane as a whole is assumed to be subjected to the loads corresponding to the load factors specified in § 23.527.

(b) In applying the loads resulting from the load factors prescribed in § 23.527, the loads may be distributed over the hull or main float bottom (in order to avoid excessive local shear loads and bending moments at the location of water load application) using pressures not less than those prescribed in § 23.533(c).

(c) For twin float seaplanes, each float must be treated as an equivalent hull on a fictitious seaplane with a weight equal to one-half the weight of the twin float seaplane.

(d) Except in the takeoff condition of § 23.531, the aerodynamic lift on the seaplane during the impact is assumed to be ⅔ of the weight of the seaplane.]

[(Amdt. 23–45, Eff. 9/7/93)]

[§ 23.527 Hull and main float load factors.

[(a) Water reaction load factors n_w must be computed in the following manner:

(1) For the step landing case

$$n_w = \frac{C_1 V_{SO}^2}{(\mathrm{Tan}^{2/3}\beta)\, W^{1/3}}$$

(2) For the bow and stern landing cases

$$n_w = \frac{C_1 V_{SO}^2}{(\mathrm{Tan}^{2/3}\beta)\, W^{1/3}} \times \frac{K_1}{(1+r_x^2)^{2/3}}$$

(b) The following values are used:

(1) n_w = water reaction load factor (that is, the water reaction divided by seaplane weight).

mined in accordance with figure 1 of appendix I of this part.

(5) W = seaplane design landing weight in pounds.

(6) K_1 = empirical hull station weighing factor, in accordance with figure 2 of appendix I of this part.

(7) r_x = ratio of distance, measured parallel to hull reference axis, from the center of gravity of the seaplane to the hull longitudinal station at which the load factor is being computed to the radius of gyration in pitch of the seaplane, the hull reference axis being a straight line, in the plane of symmetry, tangential to the keel at the main step.

(c) For a twin float seaplane, because of the effect of flexibility of the attachment of the floats to the seaplane, the factor K_1 may be reduced at the bow and stern to 0.8 of the value shown in figure 2 of appendix I of this part. This reduction applies only to the design of the carrythrough and seaplane structure.]

[(Amdt. 23–45, Eff. 9/7/93)]

[§ 23.529 Hull and main float landing conditions.

[(a) *Symmetrical step, bow, and stern landing.* For symmetrical step, bow, and stern landings, the limit water reaction load factors are those computed under § 23.527. In addition—

(1) For symmetrical step landings, the resultant water load must be applied at the keel, through the center of gravity, and must be directed perpendicularly to the keel line;

(2) For symmetrical bow landings, the resultant water load must be applied at the keel, one-fifth of the longitudinal distance from the bow to the step, and must be directed perpendicularly to the keel line; and

(3) For symmetrical stern landings, the resultant water load must be applied at the keel, at a point 85 percent of the longitudinal distance

the resultant load in the corresponding symmetrical landing condition; and

(2) The point of application and direction of the upward component of the load is the same as that in the symmetrical condition, and the point of application of the side component is at the same longitudinal station as the upward component but is directed inward perpendicularly to the plane of symmetry at a point midway between the keel and the chine lines.

(c) *Unsymmetrical landing; twin float seaplanes.* The unsymmetrical loading consists of an upward load at the step of each float of 0.75 and a side load of 0.25 tan β at one float times the step landing load reached under § 23.527. The side load is directed inboard, perpendicularly to the plane of symmetry midway between the keel and chine lines of the float, at the same longitudinal station as the upward load.]

[(Amdt. 23–45, Eff. 9/7/93)]

[§ 23.531 Hull and main float takeoff condition.

[For the wing and its attachment to the hull or main float—

(a) The aerodynamic wing lift is assumed to be zero; and

(b) A downward inertia load, corresponding to a load factor computed from the following formula, must be applied:

$$n = \frac{C_{TO} V_{S1}^{2}}{(\mathrm{Tan}^{2/3}\beta)W^{1/3}}$$

where—

n = inertia load factor;

C_{TO} = empirical seaplane operations factor equal to 0.004;

V_{S1} = seaplane stalling speed (knots) at the design takeoff weight with the flaps extended in the appropriate takeoff position;

β = angle of dead rise at the main step (degrees); and

W = design water takeoff weight in pounds.]

[(Amdt. 23–45, Eff. 9/7/93)]

(1) For an unflared bottom, the pressure at the chine is 0.75 times the pressure at the keel, and the pressures between the keel and chine vary linearly, in accordance with figure 3 of appendix I of this part. The pressure at the keel (p.s.i.) is computed as follows:

$$P_k = \frac{C_2 K_2 V_{S1}^2}{\operatorname{Tan} \beta_k}$$

where—

P_k = pressure (p.s.i.) at the keel;
C_2 = 0.00213;
K_2 = hull station weighing factor, in accordance with figure 2 of appendix I of this part;
V_{S1} = seaplane stalling speed (knots) at the design water takeoff weight with flaps extended in the appropriate takeoff position; and
β_K = angle of dead rise at keel, in accordance with figure 1 of appendix I of this part.

(2) For a flared bottom, the pressure at the beginning of the flare is the same as that for an unflared bottom, and the pressure between the chine and the beginning of the flare varies linearly, in accordance with figure 3 of appendix I of this part. The pressure distribution is the same as that prescribed in paragraph (b)(1) of this section for an unflared bottom except that the pressure at the chine is computed as follows:

$$P_{ch} = \frac{C_3 K_2 V_{S1}^2}{\operatorname{Tan} \beta}$$

where—

P_{ch} = pressure (p.s.i.) at the chine;
C_3 = 0.0016;
K_2 = hull station weighing factor, in accordance with figure 2 of appendix I of this part;
V_{S1} = seaplane stalling speed (knots) at the design water takeoff weight with flaps extended in the appropriate takeoff position; and
β = angle of dead rise at appropriate station.

The area over which these pressures are applied must simulate pressures occuring during high localized impacts on the hull or float, but need not extend over an area that would induce critical stresses in the frames or in the overall structure.

P = pressure (p.s.i.);
C_4 = 0.078 C_1 (with C_1 computed under § 23.527);
K_2 = hull station weighing factor, determined in accordance with figure 2 of appendix I of this part;
V_{S0} = seaplane stalling speed (knots) with landing flaps extended in the appropriate position and with no slipstream effect; and
β = angle of dead rise at appropriate station.

(2) The unsymmetrical pressure distribution consists of the pressures prescribed in paragraph (c)(1) of this section on one side of the hull or main float centerline and one-half of that pressure on the other side of the hull or main float centerline, in accordance with figure 3 of appendix I of this part.

(3) These pressures are uniform and must be applied simultaneously over the entire hull or main float bottom. The loads obtained must be carried into the sidewall structure of the hull proper, but need not be transmitted in a fore and aft direction as shear and bending loads.]

[(Amdt. 23–45, Eff. 9/7/93)]

[§ 23.535 Auxiliary float loads.

[(a) *General.* Auxiliary floats and their attachments and supporting structures must be designed for the conditions prescribed in this section. In the cases specified in paragraphs (b) through (e) of this section, the prescribed water loads may be distributed over the float bottom to avoid excessive local loads, using bottom pressures not less than those prescribed in paragraph (g) of this section.

(b) *Step loading.* The resultant water load must be applied in the plane of symmetry of the float at a point three-fourths of the distance from the bow to the step and must be perpendicular to the keel. The resultant limit load is computed as follows, except that the value of L need not exceed three times the weight of the displaced water when the float is completely submerged:

$$L = \frac{C_5 V_{S0}^2 W^{2/3}}{\operatorname{Tan}^{2/3} \beta_s (1 + r_y^2)^{2/3}}$$

where—

and the plane of symmetry of the float to the radius of gyration in roll.

(c) *Bow loading.* The resultant limit load must be applied in the plane of symmetry of the float at a point one-fourth of the distance from the bow to the step and must be perpendicular to the tangent to the keel line at that point. The magnitude of the resultant load is that specified in paragraph (b) of this section.

(d) *Unsymmetrical step loading.* The resultant water load consists of a component equal to 0.75 times the load specified in paragraph (a) of this section and a side component equal to 0.25 tan β times the load specified in paragraph (b) of this section. The side load must be applied perpendicularly to the plane of symmetry of the float at a point midway between the keel and the chine.

(e) *Unsymmetrical bow loading.* The resultant water load consists of a component equal to 0.75 times the load specified in paragraph (b) of this section and a side component equal to 0.25 tan β times the load specified in paragraph (c) of this section. The side load must be applied perpendicularly to the plane of symmetry at a point midway between the keel and the chine.

(f) *Immersed float condition.* The resultant load must be applied at the centroid of the cross section of the float at a point one-third of the distance from the bow to the step. The limit load components are as follows:

vertical $= \rho g V$;

$$\text{aft} = \frac{C_X \rho\, V^{2/3} (K\, V_{SO})^2}{2};$$

$$\text{side} = \frac{C_Y \rho\, V^{2/3} (K\, V_{SO})^2}{2};$$

where—

ρ = mass density of water (slugs/ft.^{3});

V = volume of float (ft.^{3});

C_X = coefficient of drag force, equal to 0.133;

C_Y = coefficient of side force, equal to 0.106;

K = 0.8, except that lower values may be used if it is shown that the floats are incapable of submerging at a speed of 0.8 V_{SO} in normal operations;

paragraph (b) of this section.]

[(Amdt. 23–45, Eff. 9/7/93)]

[§ 23.537 Seawing loads.

[Seawing design loads must be based on applicable test data.]

[(Amdt. 23–45, Eff. 9/7/93)]

EMERGENCY LANDING CONDITIONS

§ 23.561 General.

(a) The airplane, although it may be damaged in emergency landing conditions, must be designed as prescribed in this section to protect each occupant under those conditions.

(b) The structure must be designed to protect each occupant during emergency landing conditions when—

(1) Proper use is made of seats, safety belts, and shoulder harnesses provided for in the design;

(2) The occupant experiences the static inertia loads corresponding to the following ultimate load factors—

(i) Upward, 3.0g for normal, utility, and commuter category airplanes, or 4.5g for acrobatic category airplanes;

(ii) Forward, 9.0g;

(iii) Sideward, 1.5g; and

(3) The items of mass within the cabin, that could injure an occupant, experience the static inertia loads corresponding to the following ultimate load factors—

(i) Upward, 3.0g;

(ii) Forward, 18.0g; and

(iii) Sideward, 4.5g.

(c) Each airplane with retractable landing gear must be designed to protect each occupant in a landing—

(1) With the wheels retracted;

(2) With moderate descent velocity; and

(3) Assuming, in the absence of a more rational analysis—

by an analysis assuming the following conditions—

(i) Maximum weight;

(ii) Most forward center of gravity position;

(iii) Longitudinal load factor of 9.0g;

(iv) Vertical load factor of 1.0g; and

(v) For airplanes with tricycle landing gear, the nose wheel strut failed with the nose contacting the ground.

(2) For determining the loads to be applied to the inverted airplane after a turnover, an upward ultimate inertia load factor of 3.0g and a coefficient of friction with the ground of 0.5 must be used.

(Amdt. 23–7, Eff. 9/14/69); (Amdt. 23–36, Eff. 9/14/88)

§ 23.562 Emergency landing dynamic conditions.

(a) Each seat/restraint system for use in a normal, utility, or acrobatic category airplane must be designed to protect each occupant during an emergency landing when—

(1) Proper use is made of seats, safety belts, and shoulder harnesses provided for the design; and

(2) The occupant is exposed to the loads resulting from the conditions prescribed in this section.

(b) [Except for those seat/restraint systems that are required to meet paragraph (d) of this section, each seat/restraint system for crew or passenger occupancy in a normal, utility, or acrobatic category airplane, must successfully complete dynamic tests or be demonstrated by rational analysis supported by dynamic tests, in accordance with each of the following conditions.] These tests must be conducted with an occupant simulated by an anthropomorphic test dummy (ATD) defined by 49 CFR part 572, subpart B, or an FAA-approved equivalent, with a nominal weight of 170 pounds and seated in the normal upright position.

(1) For the first test, the change in velocity may not be less than 31 feet per second. The seat/restraint system must be oriented in its nominal position with respect to the airplane and with

(2) For the second test, the change in velocity may not be less than 42 per second. The seat/restraint system must be oriented in its nominal position with respect to the airplane and with the vertical plane of the airplane yawed 10°, with no pitch, relative to the impact vector in a direction that results in the greatest load on the shoulder harness. For seat/restraint systems to be installed in the first row of the airplane, peak deceleration must occur in not more than 0.05 seconds after impact and must reach a minimum of 26g. For all other seat/restraint systems, peak deceleration must occur in not more than 0.06 seconds after impact and must reach and minimum of 21g.

(3) To account for floor warpage, the floor rails of attachment devices used to attach the seat/restraint system to the airframe structure must be preloaded to misalign with respect to each other by at least 10° vertically (i.e., pitch out of parallel) and one of the rails or attachment devices must be preloaded to misalign by 10 degrees in roll prior to conducting the test defined by paragraph (b)(2) of this section.

(c) Compliance with the following requirements must be shown during the dynamic tests conducted in accordance with paragraph (b) of this section:

(1) The seat/restraint system must restrain the ATD although seat/restraint system components may experience deformation, elongation, displacement, or crushing intended as part of the design.

(2) The attachment between the seat/restraint system and the test fixture must remain intact, although the seat structure may have deformed.

(3) Each shoulder harness strap must remain on the ATD's shoulder during the impact.

(4) The safety belt must remain on the ATD's pelvis during the impact.

(5) The results of the dynamic tests must show that the occupant is protected from serious head injury.

(i) When contact with adjacent seats, structure, or other items in the cabin can occur, protection must be provided so that head impact does not exceed a head injury criteria (HIC) of 1,000.

expressed in seconds, and a(t) is the resultant deceleration at the center of gravity of the head form expressed as a multiple of g (units of gravity).

(iii) Compliance with the HIC limit must be demonstrated by measuring the head impact during dynamic testing as prescribed in paragraphs (b)(1) and (b)(2) of this section or by a separate showing of compliance with the head injury criteria using test or analysis procedures.

(6) Loads in individual shoulder harness straps may not exceed 1,750 pounds. If dual straps are used for retaining the upper torso, the total strap loads may not exceed 2,000 pounds.

(7) The compression load measured between the pelvis and the lumbar spine of the ATD may not exceed 1,500 pounds.

[(d) For all single-engine airplanes with a V_{SO} of more than 61 knots at maximum weight, and those multiengine airplanes of 6,000 pounds or less maximum weight with a V_{SO} of more than 61 knots at maximum weight that do not comply with § 23.67(b)(2)(i):

[(1) The ultimate load factors of § 23.561(b) must be increased by multiplying the load factors by the square of the ratio of the increased stall speed to 61 knots. The increased ultimate load factors need not exceed the values reached at a V_{SO} of 79 knots. The upward ultimate load factor for acrobatic category airplanes need not exceed 5.0g.

[(2) The seat/restraint system test required by paragraph (b)(1) of this section must be conducted in accordance with the following criteria:

[(i) The change in velocity may not be less than 31 feet per second.

[(ii)(A) The peak deceleration (g_p) of 19g and 15g must be increased and multiplied by the square of the ratio of the increased stall speed to 61 knots:

$$g_p = 19.0\ (V_{SO}/61)^2 \text{ or } g_p = 15.0\ (V_{SO}/61)^2$$

[(B) The peak deceleration need not exceed the value reached at a V_{SO} of 79 knots.

t_r = The rise time (in seconds) to the peak deceleration.]

([e]) An alternate approach that achieves an equivalent, or greater, level of occupant protection to that required by this section may be used if substantiated on a rational basis.

(Amdt. 23–36, Eff. 9/14/88); [(Amdt. 23–44, Eff. 8/18/93)]

FATIGUE EVALUATION

§ 23.571 Pressurized cabin.

The strength, detail design, and fabrication of the pressure cabin structure must be evaluated under [one] of the following:

(a) A fatigue strength investigation, in which the structure is shown by analysis, tests, or both to be able to withstand the repeated loads of variable magnitude expected in service. Analysis alone is considered acceptable only when it is conservative and applied to simple structures.

(b) A fail safe strength investigation, in which it is shown by analysis, tests, or both that catastrophic failure of the structure is not probable after fatigue failure, or obvious partial failure, of a principal structural element, and that the remaining structures are able to withstand a static ultimate load factor of 75 percent of the limit load factor at V_C, considering the combined effects of normal operating pressures, expected external aerodynamic pressures, and flight loads. These loads must be multiplied by a factor of 1.15 unless the dynamic effect of failure under static load are otherwise considered.

[(c) The damage tolerance evaluation of § 23.573(b).]

(Amdt. 23–14, Eff. 12/20/73); [(Amdt. 23–45, Eff. 9/7/93)]

§ 23.572 Wing, empennage, and associated structures.

(a) The strength, detail design, and fabrication of those parts of the wings (including canards, tandem wings, and winglets/tip fins), empennage, their to be able to withstand the repeated loads of variable magnitude expected in service. Analysis alone is acceptable only when it is conservative and applied to simple structures; or

(2) A fail safe strength investigation in which it is shown by analysis, tests, or both, that catastrophic failure of the structure is not probable after fatigue failure, or obvious partial failure, of a principal structural element, and that the remaining structure is able to withstand a static ultimate load factor of 75 percent of the critical limit load at V_C. These loads must be multiplied by a factor of 1.15 unless the dynamic effects of failure under static load are otherwise considered.

[(3) The damage tolerance evaluation of § 23.573(b).]

(b) Each evaluation required by this section must—

(1) Include typical loading spectra (e.g., taxi, ground-air-ground cycles, maneuver, gust);

(2) Account for any significant effects due to the mutual influence of aerodynamic surfaces; and

(3) Consider any significant effects from propeller slipstream loading, and buffet from vortex impingements.

(Amdt. 23–7, Eff. 9/14/69); (Amdt. 23–14, Eff. 12/20/73); (Amdt. 23–34, Eff. 2/17/87); (Amdt. 23–38, Eff. 10/26/89); [(Amdt. 23–45, Eff. 9/7/93)]

[§ 23.573 Damage tolerance and fatigue evaluation of structure.

[(a) *Composite airframe structure.* Composite airframe structure must be evaluated under this paragraph instead of §§ 23.571 and 23.572. The applicant must evaluate the composite airframe structure, the failure of which would result in catastrophic loss of the airplane, in each wing (including canards, tandem wings, and winglets), empennage, their carrythrough and attaching structure, moveable control surfaces and their attaching structure, fuselage, and pressure cabin using the damage-tolerance criteria prescribed in paragraphs (a)(1) strength and durability properties of the composite materials must be accounted for in the evaluations required by this section.

(1) It must be demonstrated by tests, or by analysis supported by tests, that the structure is capable of carrying ultimate load with damage up to the threshold of detectability considering the inspection procedures employed.

(2) The growth rate or no-growth of damage that may occur from fatigue, corrosion, manufacturing flaws or impact damage, under repeated loads expected in service, must be established by tests or analysis supported by tests.

(3) The structure must be shown by residual strength tests, or analysis supported by residual strength tests, to be able to withstand critical limit flight loads, considered as ultimate loads, with the extent of detectable damage consistent with the results of the damage tolerance evaluations. For pressurized cabins, the following loads must be withstood:

(i) Critical limit flight loads with the combined effects of normal operating pressure and expected external aerodynamic pressures.

(ii) The expected external aerodynamic pressures in 1g flight combined with a cabin differential pressure equal to 1.1 times the normal operating differential pressure without any other load.

(4) The damage growth, between initial detectability and the value selected for residual strength demonstrations, factored to obtain inspection intervals, must allow development of an inspection program suitable for application by operation and maintenance personnel.

(5) The limit load capacity of each bonded joint must be substantiated by one of the following methods:

(i) The maximum disbonds of each bonded joint consistent with the capability to withstand the loads in paragraph (a)(3) of this section must be determined by analysis, tests, or both. Disbonds of each bonded joint greater than this must be prevented by design features; or

(ii) Proof testing must be conducted on each production article that will apply the critical stand the repeated loads of variable magnitude expected in service. Sufficient component, subcomponent, element, or coupon tests must be done to establish the fatigue scatter factor and the environmental effects. Damage up to the threshold of detectability and ultimate load residual strength capability must be considered in the demonstration.

(b) *Metallic airframe structure.* If the applicant elects to use § 23.571(c) or § 23.572(a)(3), then the damage tolerance evaluation must include a determination of the probable locations and modes of damage due to fatigue, corrosion, or accidental damage. The determination must be by analysis supported by test evidence and, if available, service experience. Damage at multiple sites due to fatigue must be included where the design is such that this type of damage can be expected to occur. The dectectable damage consistent with the results of the damage tolerance evaluations. For pressurizing cabins, the following load must be withstood:

(1) The normal operating differential pressure combined with the expected external aerodynamic pressures applied simultaneously with the flight loading conditions specified in this part, and

(2) The expected external aerodynamic pressures in 1g flight combined with a cabin differential pressure equal to 1.1 times the normal operating differential pressure without any other load.

(c) *Inspection.* Based on evaluations required by this section, inspections or other procedures must be established as necessary to prevent catastrophic failure and must be included in the Airworthiness Limitations section of the Instructions for Continued Airworthiness required by § 23.1529.]

[(Amdt. 23–45, Eff. 9/7/93)]

(1) Be established by experience or tests;

(2) Meet approved specifications that ensure their having the strength and other properties assumed in the design data; and

(3) Take into account the effects of environmental conditions, such as temperature and humidity, expected in service.

(b) Workmanship must be of a high standard.

(Amdt. 23–17, Eff. 2/1/77); (Amdt. 23–23, Eff. 12/1/78)

§ 23.605 Fabrication methods.

(a) The methods of fabrication used must produce consistently sound structures. If a fabrication process (such as gluing, spot welding, or heat-treating) requires close control to reach this objective, the process must be performed under an approved process specification.

(b) Each new aircraft fabrication method must be substantiated by a test program.

(Amdt. 23–23, Eff. 12/1/78)

§ 23.607 Self-locking nuts.

No self-locking nut may be used on any bolt subject to rotation in operation unless a non friction locking device is used in addition to the self-locking device.

(Amdt. 23–17, Eff. 2/1/77)

§ 23.609 Protection of structure.

Each part of the structure must—

(a) Be suitably protected against deterioration or loss of strength in service due to any cause, including—

(including inspection of principal structural elements and control systems), close examination, repair, and replacement of each part requiring maintenance, adjustments for proper alignment and function, lubrication or servicing.

(Amdt. 23–7, Eff. 9/14/69)

§ 23.613 Material strength properties and design values.

(a) Material strength properties must be based on enough tests of material meeting specifications to establish design values on a statistical basis.

(b) [Design values must be chosen to minimize the probability of structural failure due to material variability. Except as provided in paragraph (e) of this section, compliance with this paragraph must be shown by selecting design values that ensure material strength with the following probability:

(1) Where applied loads are eventually distributed through a single member within an assembly, the failure of which would result in loss of structural integrity of the component; 99 percent probability with 95 percent confidence.

(2) For redundant structure, in which the failure of individual elements would result in applied loads being safely distributed to other load carrying members; 90 percent probability with 95 percent confidence.]

(c) [The effects of temperature on allowable stresses used for design in an essential component or structure must be considered where thermal effects are significant under normal operating conditions.

[(d) The design of the structure must minimize the probability of catastrophic fatigue failure, particularly at points of stress concentration.

(Amdt. 23–23, Eff. 12/1/78); [(Amdt. 23–45, Eff. 9/7/93)]

§ 23.615 Design properties. [Removed]

(Amdt. 23–7, Eff. 9/14/69); [(Amdt. 23–45, Eff. 9/7/93)]

§ 23.619 Special factors.

The factor of safety prescribed in § 23.303 must be multiplied by the highest pertinent special factors of safety prescribed in §§ 23.621 through 23.625 for each part of the structure whose strength is—

(1) Uncertain;

(2) Likely to deteriorate in service before normal replacement; or

(3) Subject to appreciable variability because of uncertainties in manufacturing processes or inspection methods.

(Amdt. 23–7, Eff. 9/14/69)

§ 23.621 Casting factors.

(a) *General.* The factors, tests, and inspections specified in paragraphs (b) through (d) of this section must be applied in addition to those necessary to establish foundry quality control. The inspections must meet approved specifications. Paragraphs (c) and (d) of this section apply to any structural castings except castings that are pressure tested as parts of hydraulic or other fluid systems and do not support structural loads.

(b) *Bearing stresses and surfaces.* The casting factors specified in paragraphs (c) and (d) of this section—

(1) Need not exceed 1.25 with respect to bearing stresses regardless of the method of inspection used; and

(2) Need not be used with respect to the bearing surfaces of a part whose bearing factor is larger than the applicable casting factor.

(c) *Critical castings.* For each casting whose failure would preclude continued safe flight and landing of the airplane or result in serious injury to occupants, the following apply:

(1) [Each critical casting must either—

procedure is established and an acceptable statistical analysis supports reduction, nondestructive inspection may be reduced from 100 percent, and applied on a sampling basis.]

(2) For each critical casting with a casting factor less than 1.50, three sample castings must be static tested and shown to meet—

(i) The strength requirements of § 23.305 at an ultimate load corresponding to a casting factor of 1.25; and

(ii) The deformation requirements of § 23.305 at a load of 1.15 times the limit load.

(3) Examples of these castings are structural attachment fittings, parts of flight control systems, control surface hinges and balance weight attachments, seat, berth, safety belt, and fuel and oil tank supports and attachments, and cabin pressure valves.

(d) *Non-critical castings.* For each casting other than those specified in paragraph (c) [or (e)] of this section, the following apply:

(1) Except as provided in paragraphs (d)(2) and (3) of this section, the casting factors and corresponding inspections must meet the following table:

Casting factor	Inspection
2.0 or more	100 percent visual.
Less than 2.0 but more than 1.5.	100 percent visual, and magnetic particle or penetrant or equivalent nondestructive inspection methods.
1.25 through 1.50.	100 percent visual, magnetic particle or penetrant, and radiographic, or approved equivalent nondestructive inspection methods.

(2) The percentage of castings inspected by nonvisual methods may be reduced below that specified in paragraph (d)(1) of this section when an approved quality control procedure is established.

(3) For castings procured to a specification that guarantees the mechanical properties of the material in the casting and provides for dem-

[(c) *Non-structural castings.* Castings used for non-structural purposes do not require evaluation, testing or close inspection.]

[(Amdt. 23–45, Eff. 9/7/93)]

§ 23.623 Bearing factors.

(a) Each part that has clearance (free fit), and that is subject to pounding or vibration, must have a bearing factor large enough to provide for the effects of normal relative motion.

(b) For control surface hinges and control system joints, compliance with the factors prescribed in §§ 23.657 and 23.693, respectively, meets paragraph (a) of this section.

(Amdt. 23–7, Eff. 9/14/69)

§ 23.625 Fitting factors.

For each fitting (a part or terminal used to join one structural member to another), the following apply:

(a) For each fitting whose strength is not proven by limit and ultimate load tests in which actual stress conditions are simulated in the fitting and surrounding structures, a fitting factor of at least 1.15 must be applied to each part of—

(1) The fitting;

(2) The means of attachment; and

(3) The bearing on the joined members.

(b) No fitting factor need be used for joint designs based on comprehensive test data (such as continuous joints in metal plating, welded joints, and scarf joints in wood).

(c) For each integral fitting, the part must be treated as a fitting up to the point at which the section properties become typical of the member.

(d) For each seat, berth, safety belt, and harness, its attachment to the structure must be shown, by analysis, tests, or both, to be able to withstand the inertia forces prescribed in § 23.561 multiplied by a fitting factor of 1.33.

(Amdt. 23–7, Eff. 9/14/69)

(a) It must be shown by one of the methods specified in paragraph (b), (c), or (d) of this section, or a combination of these methods, that the airplane is free from flutter, control reversal, and divergence for any condition of operation within the limit V–*n* envelope, and at all speeds up to the speed specified for the selected method. In addition—

(1) Adequate tolerances must be established for quantities which affect flutter; including speed, damping, mass balance, and control system stiffness; and

(2) The natural frequencies of main structural components must be determined by vibration tests or other approved methods.

(b) A rational analysis may be used to show that the airplane is free from flutter, control reversal, and divergence if the analysis shows freedom from flutter for all speeds up to 1.2 V_D.

(c) Flight flutter tests may be used to show that the airplane is free from flutter, control reversal, and divergence if it is shown by these tests that—

(1) Proper and adequate attempts to induce flutter have been made within the speed range up to V_D;

(2) The vibratory response of the structure during the test indicates freedom from flutter;

(3) A proper margin of damping exists at V_D; and

(4) There is no large and rapid reduction in damping as V_D is approached.

(d) Compliance with the rigidity and mass balance criteria (pages 4–12), in Airframe and Equipment Engineering Report No. 45 (as corrected) ''Simplified Flutter Prevention Criteria'' (published by the Federal Aviation Administration) may be accomplished to show that the airplane is free from flutter, control reversal, or divergence if—

(1) [V_D/M_D for the airplane is less than 260 knots (EAS) and less than Mach 0.5,]

(2) The wing and aileron flutter prevention criteria, as represented by the wing torsional stiffness and aileron balance criteria, are limited in use to airplanes without large mass concentrations (such as engines, floats, or fuel tanks in outer wing panels) along the wing span, and

(3) The airplane—

(1) Whirl mode degree of freedom which takes into account the stability of the plane of rotation of the propeller and significant elastic, inertial, and aerodynamic forces, and

(2) Propeller, engine, engine mount, and airplane structure stiffness and damping variations appropriate to the particular configuration.

(f) Freedom from flutter, control reversal, and divergence up to V_D/M_D must be shown as follows:

(1) For airplanes that meet the criteria of paragraphs (d)(1) through (3) of this section, after the failure, malfunction, or disconnection of any single element in any tab control system.

(2) For airplanes other than those described in paragraph (f)(1) of this section, after the failure, malfunction, or disconnection of any single element in the primary flight control system, any tab control system, or any flutter damper.

[(g) For airplanes showing compliance with the fail-safe criteria of §§ 23.571 and 23.572, the airplane must be shown by analysis or test to be free from flutter to V_D/M_D after fatigue failure, or obvious partial failure of a principal structural element.

[(h) For airplanes showing compliance with the damage-tolerance criteria of § 23.573, the airplane must be shown by analysis or test to be free from flutter to V_D/M_D with the extent of damage for which residual strength is demonstrated.]

(Amdt. 23–7, Eff. 9/14/69); (Amdt. 23–23, Eff. 12/1/78); (Amdt. 23–31, Eff. 12/28/84); [(Amdt. 23–45, Eff. 9/7/93)]

WINGS

§ 23.641 Proof of strength.

The strength of stressed-skin wings must be proven by load tests or by combined structural analysis and load tests.

of conservative manner.

§ 23.655 Installation.

(a) [Movable surfaces must be installed so that there is no interference between any surfaces, their bracing, or adjacent fixed structure, when one surface is held in its most critical clearance positions and the others are operated through their full movement.]

(b) If an adjustable stabilizer is used, must have stops that will limit its range of travel to that allowing safe flight and landing.

[(Amdt. 23–45, Eff. 9/7/93)]

§ 23.657 Hinges.

(a) Control surface hinges, except ball and roller bearing hinges, must have a factor of safety of not less than 6.67 with respect to the ultimate bearing strength of the softest material used as a bearing.

(b) For ball or roller bearing hinges, the approved rating of the bearing may not be exceeded.

(c) Hinges must have enough strength and rigidity for loads parallel to the hinge line.

§ 23.659 Mass balance.

The supporting structure and the attachment of concentrated mass balance weights used on control surfaces must be designed for—

(a) 24g normal to the plane of the control surface;

(b) 12g fore and aft; and

(c) 12g parallel to the hinge line.

CONTROL SYSTEMS

§ 23.671 General.

(a) Each control must operate easily, smoothly, and positively enough to allow proper performance of its functions.

(b) Controls must be arranged and identified to provide for convenience in operation and to prevent the possibility of confusion and subsequent inadvertent operation.

requiring the pilot's attention, must be provided for any failure in the stability augmentation system or in any other automatic or power-operated system that could result in an unsafe condition if the pilot was not aware of the failure. Warning systems must not activate the control system.

(b) The design of the stability augmentation system or of any other automatic or power-operated system must permit initial counteraction of failures without requiring exceptional pilot skill or strength, by either the deactivation of the system or a failed portion thereof, or by overriding the failure by movement of the flight controls in the normal sense.

(c) It must be shown that, after any single failure of the stability augmentation system or any other automatic or power-operated system—

(1) The airplane is safely controllable when the failure or malfunction occurs at any speed or altitude within the approved operating limitations that is critical for the type of failure being considered;

(2) The controllability and maneuverability requirements of this part are met within a practical operational flight envelope (for example, speed, altitude, normal acceleration, and airplane configuration) that is described in the Airplane Flight Manual (AFM); and

(3) The trim, stability, and stall characteristics are not impaired below a level needed to permit continued safe flight and landing.]

[(Amdt. 23–45, Eff. 9/7/93)]

§ 23.673 Primary flight controls.

(a) Primary flight controls are those used by the pilot for the immediate control of pitch, roll, and yaw.

(b) The design of two-control airplanes must minimize the likelihood of complete loss of lateral or directional control in the event of failure of any connecting or transmitting element in the control system.

(c) Each stop must be able to withstand any loads corresponding to the design conditions for the control system.

(Amdt. 23–17, Eff. 2/1/77)

§ 23.677 Trim systems.

(a) Proper precautions must be taken to prevent inadvertent, improper, or abrupt trim tab operation. There must be means near the trim control to indicate to the pilot the direction of trim control movement relative to airplane motion. In addition, there must be means to indicate to the pilot the position of the trim device with respect to the range of adjustment. This means must be visible to the pilot and must be located and designed to prevent confusion.

(b) Trimming devices must be designed so that, when any one connecting or transmitting element in the primary flight control system fails, adequate control for safe flight and landing is available with—

(1) For single-engine airplanes, the longitudinal trimming devices; or

(2) For multiengine airplanes, the longitudinal and directional trimming devices.

(c) Tab controls must be irreversible unless the tab is properly balanced and has no unsafe flutter characteristics. Irreversible tab systems must have adequate rigidity, and reliability in the portion of the system from the tab to the attachment of the irreversible unit to the airplane structure.

(d) It must be demonstrated that the airplane is safely controllable and that the pilot can perform all maneuvers and operations necessary to effect a safe landing following any probable powered trim system runaway that reasonably might be expected in service, allowing for appropriate time delay after pilot recognition of the trim system runaway. The demonstration must be conducted at critical airplane weights and center of gravity positions.

(Amdt. 23–7, Eff. 9/14/69); (Amdt. 23–34, Eff. 2/17/87); (Amdt. 23–42, Eff. 2/4/91) a normal manner.

(b) The device must be installed to limit the operation of the airplane so that, when the device is engaged, the pilot receives unmistakable warning at the start of takeoff.

(c) The device must have a means to preclude the possibility of it becoming inadvertently engaged in flight.]

[(Amdt. 23–45, Eff. 9/7/93)]

§ 23.681 Limit load static tests.

(a) Compliance with the limit load requirements of this part must be shown by tests in which—

(1) The direction of the test loads produces the most severe loading in the control system; and

(2) Each fitting, pulley, and bracket used in attaching the system to the main structure is included.

(b) Compliance must be shown (by analyses or individual load tests) with the special factor requirements for control system joints subject to angular motion.

§ 23.683 Operation tests.

(a) It must be shown by operation tests that, when the controls are operated from the pilot compartment with the system loaded as prescribed in paragraph (b) of this section, the system is free from—

(1) Jamming;

(2) Excessive friction; and

(3) Excessive deflection.

(b) The prescribed test loads are—

(1) For the entire system, loads corresponding to the limit airloads on the appropriate surface, or the limit pilot forces in § 23.397(b), whichever are less; and

(2) For secondary controls, loads not less than those corresponding to the maximum pilot effort established under § 23.405.

(Amdt. 23–7, Eff. 9/14/69)

of cables or tubes against other parts.

(d) Each element of the flight control system must have design features, or must be distinctively and permanently marked, to minimize the possibility of incorrect assembly that could result in malfunctioning of the control system.

(Amdt. 23–17, Eff. 2/1/77)

§ 23.687 Spring devices.

The reliability of any spring device used in the control system must be established by tests simulating service conditions unless failure of the spring will not cause flutter or unsafe flight characteristics.

§ 23.689 Cable systems.

(a) Each cable, cable fitting, turnbuckle, splice, and pulley used must meet approved specifications. In addition—

(1) No cable smaller than ⅛ inch diameter may be used in primary control systems;

(2) Each cable system must be designed so that there will be no hazardous change in cable tension throughout the range of travel under operating conditions and temperature variations; and

(3) There must be means for visual inspection at each fairlead, pulley, terminal, and turnbuckle.

(b) Each kind and size of pulley must correspond to the cable with which it is used. Each pulley must have closely fitted guards to prevent the cables from being misplaced or fouled, even when slack. Each pulley must lie in the plane passing through the cable so that the cable does not rub against the pulley flange.

(c) Fairleads must be installed so that they do not cause a change in cable direction of more than 3°.

(d) Clevis pins subject to load or motion and retained only by cotter pins may not be used in the control system.

(e) Turnbuckles must be attached to parts having angular motion in a manner that will positively prevent binding throughout the range of travel.

are subject to angular motion, except those in ball and roller bearing systems, must have a special factor of safety of not less than 3.33 with respect to the ultimate bearing strength of the softest material used as a bearing. This factor may be reduced to 2.0 for joints in cable control systems. For ball or roller bearings, the approved ratings may not be exceeded.

§ 23.697 Wing flap controls.

(a) Each wing flap control must be designed so that, when the flap has been placed in any position upon which compliance with the performance requirements of this part is based, the flap will not move from that position unless the control is adjusted or is moved by the automatic operation of a flap load limiting device.

(b) The rate of movement of the flaps in response to the operation of the pilot's control or automatic device must give satisfactory flight and performance characteristics under steady or changing conditions of airspeed, engine power, and attitude.

§ 23.699 Wing flap position indicator.

There must be a wing flap position indicator for—

(a) Flap installations with only the retracted and fully extended position, unless—

(1) A direct operating mechanism provides a sense of "feel" and position (such as when a mechanical linkage is employed); or

(2) The flap position is readily determined without seriously detracting from other piloting duties under any flight condition, day or night; and

(b) Flap installation with intermediate flap positions if—

(1) Any flap position other than retracted or fully extended is used to show compliance with the performance requirements of this part; and

(2) The flap installation does not meet the requirements of paragraph (a)(1) of this section.

(b) The airplane must be shown to have safe flight characteristics with any combination of extreme positions of individual movable surfaces (mechanically interconnected surfaces are to be considered as a single surface.)

(c) If an interconnection is used in multiengine airplanes, it must be designed to account for the unsymmetrical loads resulting from flight with the engines on one side of the plane of symmetry inoperative and the remaining engines at takeoff power. For single-engine airplanes, and multiengine airplanes with no slipstream effects on the flaps, it may be assumed that 100 percent of the critical air load acts on one side and 70 percent on the other.

(Amdt. 23–14, Eff. 12/20/73); (Amdt. 23–42, Eff. 2/4/91)

LANDING GEAR

§ 23.721 General.

For commuter category airplanes that have a passenger seating configuration, excluding pilot seats, of 10 or more, the following general requirements for the landing gear apply:

(a) The main landing-gear system must be designed so that if it fails due to overloads during takeoff and landing (assuming the overloads to act in the upward and aft directions), the failure mode is not likely to cause the spillage of enough fuel from any part of the fuel system to constitute a fire hazard.

(b) Each airplane must be designed so that, with the airplane under control, if can be landed on a paved runway with any one or more landing-gear legs not extended without sustaining a structural component failure that is likely to cause the spillage of enough fuel to constitute a fire hazard.

(c) Compliance with the provisions of this section may be shown by analysis or tests, or both.

(Amdt. 23–7, Eff. 9/14/69); (Amdt. 23–34, Eff. 2/17/87) ing weights.

(b) The landing gear may not fail, but may yield, in a test showing its reserved energy absorption capacity, simulating a descent velocity of 1.2 times the limit descent velocity, assuming wing lift equal to the weight of the airplane.

(Amdt. 23–23, Eff. 12/1/78)

§ 23.725 Limit drop tests.

(a) If compliance with § 23.723(a) is shown by free drop tests, these tests must be made on the complete airplane, or on units consisting of wheel, tire, and shock absorber, in their proper relation, from free drop heights not less than those determined by the following formula:

$$h \text{ (inches)} = 3.6 \, (W/S)^{1/2}$$

However, the free drop height may not be less than 9.2 inches and need not be more than 18.7 inches.

(b) If the effect of wing lift is provided for in free drop tests, the landing gear must be dropped with an effective weight equal to—

$$W_e = W \frac{h + (1 - L)d}{h + d}$$

where—

W_e=the effective weight to be used in the drop test (lbs.);

h=specified free drop height (inches);

d=deflection under impact of the tire (at the approved inflation pressure) plus the vertical component of the axle travel relative to the drop mass (inches);

$W=W_M$ for main gear units (lbs.), equal to the static weight on that unit with the airplane in the level attitude (with the nose wheel clear in the case of the nose wheel type airplanes);

$W=W_T$ for tail gear units (lbs.), equal to the static weight on the tail unit with the airplane in the tail-down attitude;

$W=W_N$ for nose wheel units (lbs.), equal to the vertical component of the static reaction that would exist at the nose wheel, assuming that the mass of the airplane acts at the center of gravity and exerts a force of 1.0g downward and 0.33g forward; and

L=the ratio of the assumed wing lift to the airplane weight, but not more than 0.667.

(c) The limit inertia load factor must be determined in a rational or conservative manner, during

$$n = n_j \frac{W_e}{W} + L$$

where—

n_j=the load factor developed in the drop test (that is, the acceleration (dv/dt) in g's recorded in the drop test) plus 1.0; and

W_e, W, and L are the same as in the drop test computation.

(f) The value of n determined in accordance with paragraph (e) may not be more than the limit inertia load factor used in the landing conditions in § 23.473.

(Amdt. 23–7, Eff. 9/14/69)

§ 23.726 Ground load dynamic tests.

(a) If compliance with the ground load requirements of §§ 23.479 through 23.483 is shown dynamically by drop test, one drop test must be conducted that meets § 23.725 except that the drop height must be—

(1) 2.25 times the drop height prescribed in § 23.725(a); or

(2) Sufficient to develop 1.5 times the limit load factor.

(b) The critical landing condition for each of the design conditions specified in §§ 23.479 through 23.483 must be used for proof of strength.

(Amdt. 23–7, Eff. 9/14/69)

§ 23.727 Reserve energy absorption drop test.

(a) If compliance with the reserve energy absorption requirement in § 23.723(b) is shown by free drop tests, the drop height may not be less than 1.44 times that specified in § 23.725.

(b) If the effect of wing lift is provided for, the units must be dropped with an effective mass equal to $W_e = Wh/(h+d)$, when the symbols and other details are the same as in § 23.725.

(Amdt. 23–7, Eff. 9/14/69)

loads, occurring during retraction at any airspeed up to 1.6 V_{S1}, with flaps retracted, and for any load factor up to those specified in § 23.345 for the flaps-extended condition.

(2) The landing gear and retracting mechanism, including the wheel well doors, must withstand flight loads, including loads resulting from all yawing conditions specified in § 23.351, with the landing gear extended at any speed up to at least 1.6 V_{S1} with the flaps retracted.

(b) *Landing gear lock.* There must be positive means (other than the use of hydraulic pressure) to keep the landing gear extended.

(c) *Emergency operation.* For a landplane having retractable landing gear that cannot be extended manually, there must be means to extend the landing gear in the event of either—

(1) Any reasonably probable failure in the normal landing gear operation system; or

(2) Any reasonably probable failure in a power source that would prevent the operation of the normal landing gear operation system.

(d) *Operation test.* The proper functioning of the retracting mechanism must be shown by operation tests.

(e) *Position indicator.* If a retractable landing gear is used, there must be a landing gear position indicator (as well as necessary switches to actuate the indicator) or other means to inform the pilot that the gear is secured in the extended (or retracted) position. If switches are used, they must be located and coupled to the landing gear mechanical system in a manner that prevents an erroneous indication of either ''down and locked'' if the landing gear is not in the fully extended position, or of ''up and locked'' if the landing gear is not in the fully retracted position. The switches may be located where they are operated by the actual landing gear locking latch or device.

(f) *Landing gear warning.* For landplanes, the following aural or equally effective landing gear warning devices must be provided:

(1) [A device that functions continuously when one or more throttles are closed beyond the power settings normally used for landing

the warning device.

(2) [A device that functions continuously when the wing flaps are extended beyond the maximum approach flap position, using a normal landing procedure, if the landing gear is not fully extended and locked. There may not be a manual shutoff for this warning device. The flap position sensing unit may be installed at any suitable location. The system for this device may use any part of the system (including the aural warning device) for the device required in paragraph (f)(1) of this section.]

(Amdt. 23–7, Eff. 9/14/69); (Amdt. 23–21, Eff. 3/1/78); (Amdt. 23–26, Eff. 10/14/80); [(Amdt. 23–45, Eff. 9/7/93)]

§ 23.731 Wheels.

[(a)] The maximum static load rating of each wheel may not be less than the corresponding static ground reaction—

(1) Design maximum weight; and

(2) Critical center of gravity.

[(b)] The maximum limit load rating of each wheel must equal or exceed the maximum radial limit load determined under the applicable ground load requirements of this part.

[(Amdt. 23–45, Eff. 9/7/93)]

§ 23.733 Tires.

(a) [Each landing gear wheel must have a tire whose approved tire ratings (static and dynamic) are not exceeded—

(1) [By a load on each main wheel tire (to be compared to the static rating approved for such tires) equal to the corresponding static ground reaction under the design maximum weight and critical center of gravity; and

(2) [By a load on nose wheel tires (to be compared with the dynamic rating approved for such tires) equal to the reaction obtained at the nose wheel, assuming the mass of the airplane to be concentrated at the most critical center of gravity and exerting a force of 1.0*W* downward and 0.31*W* forward (where *W* is the design maxi-

(c) Each tire installed on a retractable landing gear system must, at the maximum size of the tire type expected in service, have a clearance to surrounding structure and systems that is adequate to prevent contact between the tire and any part of the structure of systems.

(Amdt. 23–7, Eff. 9/14/69); (Amdt. 23–17, Eff. 2/1/77); [(Amdt. 23–45, Eff. 9/7/93)]

§ 23.735 Brakes.

(a) Brakes must be provided so that the brake kinetic energy capacity rating of each main wheel brake assembly is not less than the kinetic energy absorption requirements determined under either of the following methods:

(1) The brake kinetic energy absorption requirements must be based on a conservative rational analysis of the sequence of events expected during landing at the design landing weight.

(2) Instead of a rational analysis, the kinetic energy absorption requirements for each main wheel brake assembly may be derived from the following formula:

$$KE=0.0443\ WV^2/N$$

where—

KE=Kinetic energy per wheel (ft.-lb.);

W=Design landing weight (lb.);

V=Airplane speed in knots. V must be not less than $V_S\surd$, the poweroff stalling speed of the airplane at sea level, at the design landing weight, and in the landing configuration; and

N=Number of main wheels with brakes.

(b) Brakes must be able to prevent the wheels from rolling on a paved runway with takeoff power on the critical engine, but need not prevent movement of the airplane with wheels locked.

(c) If antiskid devices are installed, the devices and associated systems must be designed so that no single probable malfunction of failure will result in a hazardous loss of braking ability or directional control of the airplane.

(Amdt. 23–7, Eff. 9/14/69); (Amdt. 23–24, Eff. 12/31/79); (Amdt. 23–42, Eff. 2/4/91)

23.751 Main float buoyancy.

(a) Each main float must have—

(1) [A buoyancy of 80 percent in excess of the bouyancy required by that float to support its portion of the maximum weight of the seaplane or amphibian in fresh water; and

(2) [Enough watertight compartments to provide reasonable assurance that the seaplane or amphibian will stay afloat without capsizing if any two compartments of the main floats are flooded.]

(b) Each main float must contain at least four watertight compartments approximately equal in volume.

[(Amdt. 23–45, Eff. 9/7/93)]

§ 23.753 Main float design.

[Each seaplane main float must meet the requirements of § 23.521.]

[(Amdt. 23–45, Eff. 9/7/93)]

§ 23.755 Hulls.

(a) The hull of a hull seaplane or amphibian of 1,500 pounds or more maximum weight must have watertight compartments designed and arranged so that the hull, auxiliary floats, and tires (if used), will keep the airplane afloat [without capsizing] in fresh water when—

(1) For airplanes of 5,000 pounds or more maximum weight, any two adjacent compartments are flooded; and

(2) For airplanes of 1,500 pounds up to, but not including 5,000 pounds maximum weight, any single compartment is flooded.

(b) The hulls of hull seaplanes or amphibians of less than 1,500 pounds maximum weight need not be compartmented.

(c) Bulkheads with watertight doors may be used for communication between compartments.

[(Amdt. 23–45, Eff. 9/7/93)]

§ 23.771 Pilot compartment.

For each pilot compartment—

(a) The compartment and its equipment must allow each pilot to perform his duties without unreasonable concentration or fatigue;

(b) Where the flight crew are separated from the passengers by a partition, an opening or openable window or door must be provided to facilitate communication between flight crew and the passengers; and

(c) The aerodynamic controls listed in § 23.779, excluding cables and control rods, must be located with respect to the propellers so that no part of the pilot or the controls lies in the region between the plane of rotation of any inboard propeller and the surface generated by a line passing through the center of the propeller hub making an angle of 50° forward or aft of the plane of rotation of the propeller.

(Amdt. 23–14, Eff. 12/20/73)

§ 23.773 Pilot compartment view.

[Each pilot compartment must be—

(1) Arranged with sufficiently extensive, clear and undistorted view to enable the pilot to safely taxi, takeoff, approach, land, and perform any maneuvers within the operating limitations of the airplane.

(2) Free from glare and reflections that could interfere with the pilot's vision. Compliance must be shown in all operations for which certification is requested; and

(3) Designed so that each pilot is protected from the elements so that moderate rain conditions do not unduly impair the pilot's view of the flight path in normal flight and while landing.

(b) Each pilot compartment must have a means to either remove or prevent the formation of fog or frost on an area of the internal portion of the windshield and side windows sufficiently large to provide the view specified in paragraph (a)(1) of this section. Compliance must be shown under all expected external and internal ambient operating

(a) Nonsplintering safety glass must be used in internal glass panes.

(b) The design of windshields, windows, and canopies in pressurized airplanes must be based on factors peculiar to high altitude operation, including—

(1) The effects of continuous and cyclic pressurization loadings;

(2) The inherent characteristics of the material used; and

(3) The effects of temperatures and temperature gradients.

(c) On pressurized airplanes that do not comply with the fail-safe requirements of paragraph (e) of this section, an enclosure canopy including a representative part of the installation must be subjected to special tests to account for the combined effects of continuous and cyclic pressurization loadings and flight loads.

(d) The windshield and side windows forward of the pilot's back when he is seated in the normal flight position must have a luminous transmittance value of not less than 70 percent.

(e) If certification for operation above 25,000 feet is requested, the windshields, window panels, and canopies must be strong enough to withstand the maximum cabin pressure differential loads combined with critical aerodynamic pressure and temperature effects, after failure of any load-carrying element of the windshield, window panel, or canopy.

[(f) Unless operation in known or forecast icing conditions is prohibited by operating limitations, a means must be provided to prevent or to clear accumulations of ice from the windshield so that the pilot has adequate view for taxi, takeoff, approach, landing, and to perform any maneuvers within the operating limitations of the airplane.

[(g) In the event of any probable single failure, a transparency heating system must be incapable of raising the temperature of any windshield or window to a point where there would be—

(1) Structural failure that adversely affects the integrity of the cabin; or

confusion and inadvertent operation.

(b) The controls must be located and arranged so that the pilot, when seated, has full and unrestricted movement of each control without interference from either his clothing or the cockpit structure.

(c) Powerplant controls must be located—

(1) For multiengine airplanes, on the pedestal or overhead at or near the center of the cockpit;

(2) For tandem seated single-engine airplanes, on the left side console or instrument panel;

(3) For other single-engine airplanes at or near the center of the cockpit, on the pedestal, instrument panel, or overhead; and

(4) For airplanes with side-by-side pilot seats and with two sets of powerplant controls, on left and right consoles.

(d) The control location order from left to right must be power (thrust) lever, propeller (rpm control), and mixture control (condition lever and fuel cutoff for turbine-powered airplanes). Power (thrust) levers must be at least one inch higher or longer to make them more prominent than propeller (rpm control) or mixture controls. Carburetor heat or alternate air control must be to the left of the throttle or at least eight inches from the mixture control when located other than on a pedestal. Carburetor heat or alternate air control, when located on a pedestal must be aft or below the power (thrust) lever. Supercharger controls must be located below or aft of the propeller controls. Airplanes with tandem seating or single-place airplanes may utilize control locations on the left side of the cabin compartment; however, location order from left to right must be power (thrust) lever, propeller (rpm control) and mixture control.

(e) Identical powerplant controls for each engine must be located to prevent confusion as to the engines they control.

(1) Conventional multiengine powerplant controls must be located so that the left control(s) operates the left engine(s) and the right control(s) operates the right engine(s).

(2) On twin-engine airplanes with front and rear engine locations (tandem), the left power-

(g) The landing gear control must be located to the left of the throttle centerline or pedestal centerline.

(h) Each fuel feed selector control must comply with § 23.995 and be located and arranged so that the pilot can see and reach it without moving any seat or primary flight control then his seat is at any position in which it can be placed.

(1) For a mechnical fuel selector:

(i) The indication of the selected fuel valve position must be by means of a pointer and must provide positive identification and feel (detent, etc.) of the selected position.

(ii) The position indicator pointer must be located at the part of the handle that is the maximum dimension of the handle measured from the center of rotation.

(2) For electrical or electronic fuel selector:

(i) Digital controls or electrical switches must be properly labelled.

(ii) Means must be provided to indicate to the flight crew the tank or function selected. Selector switch position is not acceptable as a means of indication. The ''off' or ''closed'' position must be indicated in red.

(3) If the fuel valve selector handle or electrical or digital selection is also a fuel shut-off selector, the off position marking must be colored red. If a separate emergency shut-off means is provided, it also must be colored red.

(Amdt. 23–7, Eff. 9/14/69); (Amdt. 23–33, Eff. 8/11/86)

§ 23.779 Motion and effect of cockpit controls.

Cockpit controls must be designed so that they operate in accordance with the following movement and actuation:

(a) Aerodynamic controls:

(1) *Primary controls:*	*Motion and effect*
Aileron	Right (clockwise) for right wing down.
Elevator	Rearward for nose up.

similar rotation of the airplane about an axis parallel to the axis control. Axis of roll trim control may be displaced to accommodate comfortable actuation by the pilot. For single-engine airplanes, direction of pilot's hand movement must be in the same sense as airplane response for rudder trim if only a portion of a rotational element is accessible.

(b) Powerplant and auxiliary controls:

(1) *Powerplant controls:*	*Motion and effect*
Power (thrust lever).	Forward to increase forward thrust and rearward to increase rearward thrust.
Propellers	Forward to increase r.p.m.
Mixture	Forward or upward for rich.
Carburetor, air heat or alternate air.	Forward or upward for cold.
Supercharger ..	Forward or upward for low blower.
Turbo-superchargers.	Forward, upward, or clockwise to increase pressure.
Rotary controls.	Clockwise from off to full on.

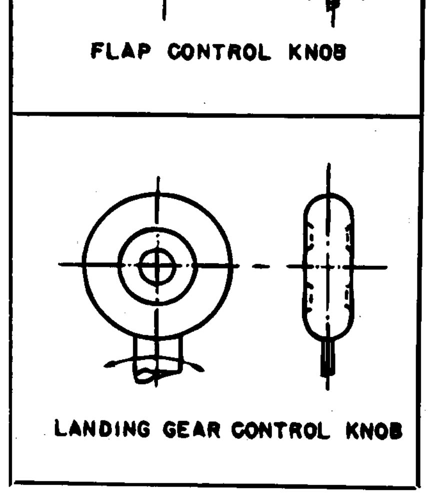
(2) *Auxiliary controls:*

Fuel tank selector.	Right for right tanks, left for left tanks.
Landing gear.	Down to extend.
Speed brakes.	Aft to extend.

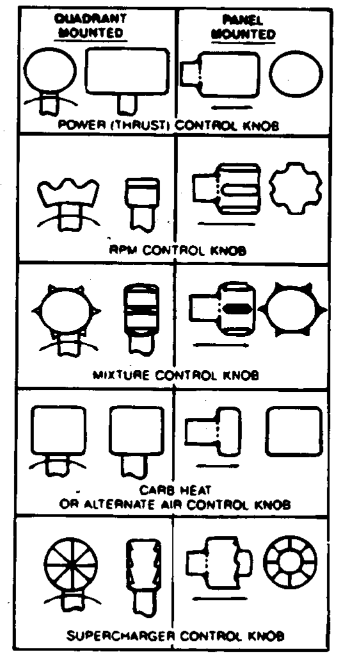
(Amdt. 23–33, Eff. 8/11/86)

§ 23.781 Cockpit control knob shape.

(a) Flap and landing gear control knobs must conform to the general shapes (but not necessarily the exact sizes or specific proportions) in the following figure:



(b) Powerplant control knobs must conform to the general shapes (but not necessarily the exact sizes of specific proportions) in the following figure:



(Amdt. 23–33, Eff. 8/11/86)

ply with the following requirements:

(1) There must be means to lock and safeguard the door against inadvertent opening during flight by persons, by cargo, or as a result of mechanical failure.

(2) The door must be openable from the inside and the outside when the internal locking mechanism is in the locked position.

(3) There must be a means of opening which is simple and obvious and is arranged and marked inside and outside so that the door can be readily located, unlocked, and opened, even in darkness.

(4) The door must meet the marking requirements of § 23.811 of this part.

(5) The door must be reasonably free from jamming as a result of fuselage deformation in an emergency landing.

(6) Auxiliary locking devices that are actuated externally to the airplane may be used but such devices must be overridden by the normal internal opening means.

(d) In addition, each external passenger or crew door, for a commuter category airplane, must comply with the following requirements:

(1) Each door must be openable from both the inside and outside, even though persons may be crowded against the door on the inside of the airplane.

(2) If inward opening doors are used, there must be a means to prevent occupants from crowding against the door to the extent that would interfere with opening the door.

(3) Auxiliary locking devices may be used.

(e) Each external door on a commuter category airplane, each external door forward of any engine or propeller on a normal, utility, or acrobatic category airplane, and each door of the pressure vessel on a pressurized airplane must comply with the following requirements:

(1) There must be a means to lock and safeguard each external door, including cargo and service type doors, against inadvertent opening in flight, by persons, by cargo, or as a result of mechanical failure or failure of a single structural element, either during or after closure.

to signal a flight crewmember if the external door is not fully closed and locked. The means must be designed so that any failure, or combination of failures, that would result in an erroneous closed and locked indication is improbable for doors for which the initial opening movement is not inward.

(Amdt. 23–34, Eff. 2/17/87); (Amdt. 23–36, Eff. 9/14/88)

§ 23.785 Seats, berths, litters, safety belts, and shoulder harnesses.

(a) Each seat/restraint system and the supporting structure must be designed to support occupants weighing at least 215 pounds when subjected to the maximum load factors corresponding to the specified flight and ground load conditions, as defined in the approved operating envelope of the airplane. In addition, these loads must be multiplied by a factor of 1.33 in determining the strength of all fittings and the attachment of—

(1) Each seat to the structure; and

(2) Each safety belt and shoulder harness to the seat or structure.

(b) Each forward-facing or aft-facing seat/restraint system in normal, utility, or acrobatic category airplanes must consist of a seat, safety belt, and shoulder harness that are designed to provide the occupant protection provisions required in § 23.562 of this part. Other seat orientations must provide the same level of occupant protection as a forward-facing or aft-facing seat with a safety belt and shoulder harness, and provide the protection provisions of § 23.562 of this part.

(c) For commuter category airplanes, each seat and the supporting structure must be designed for occupants weighing at least 170 pounds when subjected to the inertia loads resulting from the ultimate static load factors prescribed in § 23.561(b)(2) of this part, and each occupant must be protected from serious head injury when subjected to the inertia loads resulting from these load factors by a safety belt and shoulder harness for the front seats; and a safety belt, or a safety belt and shoulder harness, for each seat other than the front seats,

§ 23.395 of this part.

(g) There must be a means to secure each safety belt and shoulder harness, when not in use, to prevent interference with the operation of the airplane and with rapid occupant egress in an emergency.

(h) Unless otherwise placarded, each seat in a utility or acrobatic category airplane must be designed to accommodate an occupant wearing a parachute.

(i) The cabin area surrounding each seat, including the structure, interior walls, instrument panel, control wheel, pedals, and seats within striking distance of the occupant's head or torso (with the restraint system fastened) must be free of potentially injurious objects, sharp edges, protuberances, and hard surfaces. If energy absorbing designs or devices are used to meet this requirement, they must protect the occupant from serious injury when the occupant is subjected to the inertia loads resulting from the ultimate static load factors prescribed in § 23.561(b)(2) of this part, or they must comply with the occupant protection provisions of § 23.562 of this part, as required in paragraphs (b) and (c) of this section.

(j) Each seat track must be fitted with stops to prevent the seat from sliding off the track.

(k) Each seat/restraint system may use design features, such as crushing or separation of certain components, to reduce occupant loads when showing compliance with the requirements of § 23.562 of this part; otherwise, the system must remain intact.

(l) For the purposes of this section, a front seat is a seat located at a flight crewmember station or any seat located alongside such a seat.

(m) Each berth, or provisions for a litter, installed parallel to the longitudinal axis of the airplane, must be designed so that the forward part has a padded end-board, canvas diaphragm, or equivalent means that can withstand the load reactions from a 215-pound occupant when subjected to the inertia loads resulting from the ultimate static load factors of § 23.561(b)(2) of this part. In addition—

(1) Each berth or litter must have an occupant restraint system and may not have corners or

approved as part of the type design and for seat and berth installations may be shown by—

(1) Structural analysis, if the structure conforms to conventional airplane types for which existing methods of analysis are known to be reliable;

(2) A combination of structural analysis and static load tests to limit load; or

(3) Static load tests to ultimate loads.

(Amdt. 23–7, Eff. 9/14/69); (Amdt. 23–19, Eff. 7/18/77); (Amdt. 23–23, Eff. 12/1/78); (Amdt. 23–32, Eff. 12/12/85); (Amdt. 23–34, Eff. 2/17/87); (Amdt. 23–36, Eff. 9/14/88)

§ 23.787 Baggage and cargo compartments.

(a) Each cargo compartment must be designed for its placarded maximum weight of contents and for the critical load distributions at the appropriate maximum load factors corresponding to the flight and ground load conditions of this part.

(b) There must be means to prevent the contents of any cargo compartment from becoming a hazard by shifting, and to protect any controls, wiring, lines, equipment or accessories whose damage or failure would affect safe operations.

(c) There must be a means to protect occupants from injury by the contents of any baggage or cargo compartment, located aft of the occupants and separated by structure, when the ultimate forward inertia load factor is 9g and assuming the maximum allowed baggage or cargo weight for the compartment.

(d) Cargo compartments must be constructed of materials which are at least flame resistant.

(e) Designs which provide for baggage or cargo to be carried in the same compartment as passengers must have a means to protect the occupants from injury when the cargo is subjected to the inertia loads resulting from the ultimate static load factors of § 23.561(b)(3) of this part, assuming the maximum allowed baggage or cargo weight for the compartment.

36, Eff. 9/14/88)

§ 23.803 Emergency evacuation.

For commuter category airplanes, an evacuation demonstration must be conducted utilizing the maximum number of occupants for which certification is desired. The demonstration must be conducted under simulated night conditions using only the emergency exits on the most critical side of the airplane. The participants must be representative of average airline passengers with no prior practice or rehearsal for the demonstration. Evacuation must be completed within 90 seconds.

(Amdt. 23–34, Eff. 2/17/87);

§ 23.807 Emergency exits.

(a) *Number and location.* Emergency exits must be located to allow escape without crowding in any probable crash attitude. The airplane must have at least the following emergency exits:

(1) For all airplanes with a seating capacity of two or more, excluding airplanes with canopies, at least one emergency exit on the opposite side of the cabin from the main door specified in § 23.783 of this part.

(2) [Reserved]

(3) If the pilot compartment is separated from the cabin by a door that is likely to block the pilot's escape in a minor crash, there must be an exit in the pilot's compartment. The number of exits required by paragraph (a)(1) of this section must then be separately determined for the passenger compartment, using the seating capacity of that compartment.

(b) *Type and operation.* Emergency exits must be movable windows, panels, canopies, or external doors, openable from both inside and outside the airplane, that provide a clear and unobstructed opening large enough to admit a 19-by-26-inch ellipse. Auxiliary locking devices used to secure the airplane must be designed to be overridden by the normal internal opening means. In addition, each emergency exit must—

(1) Be readily accessible, requiring no exceptional agility to be used in emergencies;

(c) *Tests.* The proper functioning of each emergency exit must be shown by tests.

(d) *Doors and exits.* In addition, for commuter category airplanes the following requirements apply:

(1) The passenger entrance door must qualify as a floor level emergency exit. If an integral stair is installed at such a passenger entry door, the stair must be designed so that when subjected to the inertia forces specified in § 23.561, and following the collapse of one or more legs of the landing gear, it will not interfere to an extent that will reduce the effectiveness of emergency egress through the passenger entry door. Each additional required emergency exit, except floor level exists, must be located over the wing or must be provided with acceptable means to assist the occupants in descending to the ground. In addition to the passenger entrance door—

(i) For a total passenger seating capacity of 15 or less, an emergency exit as defined in paragraph (b) of this section is required on each side of the cabin; and

(ii) For a total passenger seating capacity of 16 through 19, three emergency exits, as defined in paragraph (b) of this section, are required with one on the same side as the door and two on the side opposite the door.

(2) A means must be provided to lock each emergency exit and to safeguard against its opening in flight, either inadvertently by persons or as a result of mechanical failure. In addition, a means for direct visual inspection of the locking mechanism must be provided to determine that each emergency exit for which the initial opening movement is outward is fully locked.

(Amdt. 23–7, Eff. 9/14/69); (Amdt. 23–10, Eff. 3/13/71); (Amdt. 23–34, Eff. 2/17/87); (Amdt. 23–36, Eff. 9/14/88)

§ 23.811 Emergency exit marking.

(a) Each emergency exit and external door in the passenger compartment must be externally marked and readily identifiable from outside the airplane by—

letters 1 inch high on a red background 2 inches high, be self-illuminated or independently, internally-electrically illuminated, and have a minimum brightness of at least 160 microlamberts. The color may be reversed if the passenger compartment illumination is essentially the same.

(Amdt. 23–36, Eff. 9/14/88)

§ 23.813 Emergency exit access.

For commuter category airplanes, access to window-type emergency exits may not be obstructed by seats or seat backs.

(Amdt. 23–36, Eff. 9/14/88)

§ 23.815 Width of aisle.

For commuter category airplanes, the width of the main passenger aisle at any point between seats must equal or exceed the values in the following table:

Number of Passenger Seats	Minimum main passenger aisle width	
	Less than 25 inches from floor	25 inches and more from floor
10 through 19	9 inches	15 inches

(Amdt. 23–34, Eff. 2/17/87)

§ 23.831 Ventilation.

(a) Each passenger and crew compartment must be suitably ventilated. Carbon monoxide concentration may not exceed one part in 20,000 parts of air.

(b) For pressurized airplanes, the ventilating air in the flightcrew and passenger compartments must be free of harmful or hazardous concentrations of gases and vapors in normal operations and in the event of reasonably probable failures or malfunctioning of the ventilating, heating, pressurization, or other systems and equipment. If accumulation of hazardous quantities of smoke in the cockpit area is reasonably probable, smoke evacuation must be readily accomplished starting with full

(a) If certification for operation over 31,000 feet is requested, the airplane must be able to maintain a cabin pressure altitude of not more than 15,000 feet in event of any probable failure or malfunction in the pressurization system.

(b) Pressurized cabins must have at least the following valves, controls, and indicators, for controlling cabin pressure:

(1) Two pressure relief valves to automatically limit the positive pressure differential to a predetermined valve at the maximum rate of flow delivered by the pressure source. The combined capacity of the relief valves must be large enough so that the failure of any one valve would not cause an appreciable rise in the pressure differential. The pressure differential is positive when the internal pressure is greater than the external.

(2) Two reverse pressure differential relief valves (or their equivalent) to automatically prevent a negative pressure differential that would damage the structure. However, one valve is enough if it is of a design that reasonably precludes its malfunctioning.

(3) A means by which the pressure differential can be rapidly equalized.

(4) An automatic or manual regulator for controlling the intake or exhaust airflow, or both, for maintaining the required internal pressures and airflow rates.

(5) Instruments to indicate to the pilot the pressure differential, the cabin pressure altitude, and the rate of change of cabin pressure altitude.

(6) Warning indication at the pilot station to indicate when the safe or preset pressure differential is exceeded and when a cabin pressure altitude of 10,000 feet is exceeded.

(7) A warning placard for the pilot if the structure is not designed for pressure differentials up to the maximum relief valve setting in combination with landing loads.

(8) A means to stop rotation of the compressor or to divert airflow from the cabin if continued rotation of an engine-driven cabin compressor or

be tested as a pressure vessel for the pressure differential specified in § 23.365(d).

(b) *Functional tests.* The following functional tests must be performed:

(1) Tests of the functioning and capacity of the positive and negative pressure differential valves, and of the emergency release valve, to simulate the effects of closed regulator valves.

(2) Tests of the pressurization system to show proper functioning under each possible condition of pressure, temperature, and moisture, up to the maximum altitude for which certification is requested.

(3) Flight tests, to show the performance of the pressure supply, pressure and flow regulators, indicators, and warning signals, in steady and stepped climbs and descents at rates corresponding to the maximum attainable within the operating limitations of the airplane, up to the maximum altitude for which certification is requested.

(4) Tests of each door and emergency exit, to show that they operate properly after being subjected to the flight tests prescribed in paragraph (b)(3) of this section.

FIRE PROTECTION

§ 23.851 Fire extinguishers.

[(a) There must be at least one hand fire extinguisher for use in the pilot compartment that is located within easy access of the pilot while seated.

(b) There must be at least one hand fire extinguisher located conveniently in the passenger compartment.—

(1) Of each airplane accommodating more than 6 passengers; and

(2) Of each commuter category airplane.

(c) For hand fire extinguishers, the following apply:

(1) The type and quantity of each extinguishing agent used must be appropriate to the kinds of fire likely to occur where that agent is to be used.

or passengers—

(a) The materials must be at least flame resistant;

(b) [Reserved]

(c) If smoking is to be prohibited, there must be a placard so stating, and if smoking is to be allowed—

(1) There must be an adequate number of self-contained, removable ashtrays; and

(2) Where the crew compartment is separated from the passenger compartment, there must be at least one illuminated sign (using either letters or symbols) notifying all passengers when smoking is prohibited. Signs which notify when smoking is prohibited must—

(i) When illuminated, be legible to each passenger seated in the passenger cabin under all probable lighting conditions; and

(ii) Be so constructed that the crew can turn the illumination on and off.

(d) In addition, for commuter category airplanes the following requirements apply:

(1) Each disposal receptacle for towels, paper, or waste must be fully enclosed and constructed of at least fire resistant materials and must contain fires likely to occur in it under normal use. The ability of the disposal receptacle to contain those fires under all probable conditions of wear, misalignment, and ventilation expected in service must be demonstrated by test. A placard containing the legible words "No Cigarette Disposal" must be located on or near each disposal receptacle door.

(2) Lavatories must have "No Smoking" or "No Smoking in Lavatory" placards located conspicuously on each side of the entry door and self-contained, removable ashtrays located conspicuously on or near the entry side of each lavatory door, except that one ashtray may serve more than one lavatory door if it can be seen from the cabin side of each lavatory door served. The placards must have red letters at least ½ inch high on a white background at least 1 inch high (a "No Smoking" symbol may be included on the placard).

(other than underseat stowage compartments and compartments for stowing small items such as magazines and maps) must be self-extinguishing when tested vertically in accordance with the applicable portions of appendix F of this part or by other equivalent methods. The average burn length may not exceed 6 inches and the average flame time after removal of the flame source may not exceed 15 seconds. Drippings from the test specimen may not continue to flame for more than an average of 3 seconds after falling.

(ii) Floor covering, textiles (including draperies and upholstery), seat cushions, padding, decorative and nondecorative coated fabrics, leather, trays and galley furnishings, electrical conduit, thermal and acoustical insulation and insulation covering, air ducting, joint and edge covering, cargo compartment liners, insulation brakes, cargo covers and transparencies, molded and thermoformed parts, air ducting joints, and trim strips (decorative and chafing), that are constructed of materials not covered in paragraph (d)(3)(iv) of this section must be self extinguishing when tested vertically in accordance with the applicable portions of appendix F of this part or other approved equivalent methods. The average burn length may not exceed 8 inches and the average flame time after removal of the flame source may not exceed 15 seconds. Drippings from the test specimen may not continue to flame for more than an average of 5 seconds after falling.

(iii) Motion picture film must be safety film meeting the Standard Specifications for Safety Photographic Film PH1.25 (available from the American National Standards Institute, 1430 Broadway, New York, NY 10018) or an FAA approved equivalent). If the film travels through ducts, the ducts must meet the requirements of paragraph (d)(3)(ii) of this section.

(iv) Acrylic windows and signs, parts constructed in whole or in part of elastomeric materials, edge-lighted instrument assemblies consisting of two or more instruments in a common housing, seatbelts, shoulder harnesses, and cargo and baggage tiedown equipment, including containers, bins, pallets, etc., used in passenger or crew compartments, may not have an average burn rate greater than 2.5 inches per minute when tested horizontally in accordance with the applicable portions of appendix F of this part or by other approved equivalent methods.

tion, and for small parts (such as knobs, handles, rollers, fasteners, clips, grommets, rub strips, pulleys, and small electrical parts) that the Administrator finds would not contribute significantly to the propagation of a fire, materials in items not specified in (d)(3)(i), (ii), (iii), or (iv) of this section may not have a burn rate greater than 4.0 inches per minute when tested horizontally in accordance with the applicable portions of appendix F of this part or by other approved equivalent methods.

(e) Lines, tanks, or equipment containing fuel, oil, or other flammable fluids may not be installed in such compartments unless adequately shielded, isolated, or otherwise protected so that any breakage or failure of such an item would not create a hazard.

(f) Airplane materials located on the cabin side of the firewall must be self-extinguishing or be located at such a distance from the firewall, or otherwise protected, so that ignition will not occur if the firewall is subjected to a flame temperature of not less than 2,000° F for 15 minutes. For self-extinguishing materials (except electrical wire and cable insulation and small parts that the Administrator finds would not contribute significantly to the propagation of a fire), a vertical self-extinguishing test must be conducted in accordance with appendix F of this part or an equivalent method approved by the Administrator. The average burn length of the material may not exceed 6 inches and the average flame time after removal of the flame source may not exceed 15 seconds. Drippings from the material test specimen may not continue to flame for more than an average of 3 seconds after falling.

(Amdt. 23–14, Eff. 12/20/73); (Amdt. 23–23, Eff. 12/1/78); (Amdt. 23–25, Eff. 3/6/80); (Amdt. 23–34, Eff. 2/17/87)

§ 23.859 Combustion heater fire protection.

(a) *Combustion heater fire regions.* The following combustion heater fire regions must be protected from fire in accordance with the applicable provisions of §§ 23.1182 through 23.1191 and 23.1203:

heater fuel system has fittings that, if they leaked, would allow fuel vapor to enter this region.

(3) The part of the ventilating air passage that surrounds the combustion chamber.

(b) *Ventilating air ducts.* Each ventilating air duct passage through any fire region must be fireproof. In addition—

(1) Unless isolation is provided by fireproof valves or by equally effective means, the ventilating air duct downstream of each heater must be fireproof for a distance great enough to ensure that any fire originating in the heater can be contained in the duct; and

(2) Each part of any ventilating duct passing through any region having a flammable fluid system must be constructed or isolated from that system so that the malfunctioning of any component of that system cannot introduce flammable fluids or vapors into the ventilating airstream.

(c) *Combustion air ducts.* Each combustion air duct must be fireproof for a distance great enough to prevent damage from backfiring or reverse flame propagation. In addition—

(1) No combustion air duct may have a common opening with the ventilating airstream unless flames from backfires or reverse burning cannot enter the ventilating airstream under any operating condition, including reverse flow or malfunctioning of the heater or its associated components; and

(2) No combustion air duct may restrict the prompt relief of any backfire that, if so restricted, could cause heater failure.

(d) *Heater controls: general.* Provision must be made to prevent the hazardous accumulation of water or ice on or in any heater control component, control system tubing, or safety control.

(e) *Heater safety controls.*

(1) Each combustion heater must have the following safety controls:

(i) Means independent of the components for the normal continuous control of air temperature, airflow, and fuel flow must be provided to automatically shut off the ignition and fuel supply to that heater at a point remote

(D) The ventilating airflow becomes inadequate for safe operation.

(ii) Means to warn the crew when any heater whose heat output is essential for safe operation has been shut off by the automatic means prescribed in paragraph (e)(1)(i) of this section.

(2) The means for complying with paragraph (e)(1)(i) of this section for any individual heater must—

(i) Be independent of components serving any other heater whose heat output is essential for safe operations; and

(ii) Keep the heater off until restarted by the crew.

(f) *Air intakes.* Each combustion and ventilating air intake must be located so that no flammable fluids or vapors can enter the heater system under any operating condition—

(1) During normal operation; or

(2) As a result of the malfunctioning of any other component.

(g) *Heater exhaust.* Heater exhaust systems must meet the provisions of §§ 23.1121 and 23.1123. In addition, there must be provisions in the design of the heater exhaust system to safely expel the products of combustion to prevent the occurrence of—

(1) Fuel leakage from the exhaust to surrounding compartments;

(2) Exhaust gas impingement on surrounding equipment or structure;

(3) Ignition of flammable fluids by the exhaust, if the exhaust is in a compartment containing flammable fluid lines; and

(4) Restrictions in the exhaust system to relieve backfires that, if so restricted, could cause heater failure.

(h) *Heater fuel systems.* Each heater fuel system must meet each powerplant fuel system requirement affecting safe heater operation. Each heater fuel system component within the ventilating airstream must be protected by shrouds so that no leakage from those components can enter the ventilating airstream.

(Amdt. 23–5, Eff. 6/4/67); (Amdt. 23–7, Eff. 9/14/69); (Amdt. 23–27, Eff. 11/19/80)

§ 23.863 Flammable fluid fire protection.

(a) In each area where flammable fluids or vapors might escape by leakage of a fluid system, there must be means to minimize the probability of ignition of the fluids and vapors, and the resultant hazard if ignition does occur.

(b) Compliance with paragraph (a) of this section must be shown by analysis or tests, and the following factors must be considered:

(1) Possible sources and paths of fluid leakage, and means of detecting leakage.

(2) Flammability characteristics of fluids, including effects of any combustible or absorbing materials.

(3) Possible ignition sources, including electrical faults, overheating of equipment, and malfunctioning of protective devices.

(4) Means available for controlling or extinguishing a fire, such as stopping flow of fluids, shutting down equipment, fireproof containment, or use of extinguishing agents.

(5) Ability of airplane components that are critical to safety of flight to withstand fire and heat.

(c) If action by the flight crew is required to prevent or counteract a fluid fire (e.g., equipment shutdown or actuation of a fire extinguisher), quick acting means must be provided to alert the crew.

(d) Each area where flammable fluids or vapors might escape by leakage of a fluid system must be identified and defined.

(Amdt. 23–23, Eff. 12/1/78)

isolators must incorporate suitable features to ensure that the engine is retained if the non-fireproof portions of the isolators deteriorate from the effects of a fire.]

(Amdt. 23–14, Eff. 12/20/73); [(Amdt. 23–45, Eff. 9/7/93)]

LIGHTNING EVALUATION

§ 23.867 Lightning protection of structure.

(a) The airplane must be protected against catastrophic effects from lightning.

(b) For metallic components, compliance with paragraph (a) of this section may be shown by—

(1) Bonding the components properly to the airframe; or

(2) Designing the components so that a strike will not endanger the airplane.

(c) For nonmetallic components, compliance with paragraph (a) of this section may be shown by—

(1) Designing the components to minimize the effect of a strike; or

(2) Incorporating acceptable means of diverting the resulting electrical current so as not to endanger the airplane.

(Amdt. 23–7, Eff. 9/14/69)

MISCELLANEOUS

§ 23.871 Leveling means.

There must be means for determining when the airplane is in a level position on the ground.

(Amdt. 23–7, Eff. 9/14/69)

(Amdt. 23–7, Eff. 9/14/69); (Amdt. 23–21 Eff. 3/1/78)

§ 23.1505 Airspeed limitations.

(a) The never-exceed speed V_{NE} must be established so that it is—

(1) Not less than 0.9 times the minimum value of V_D allowed under § 23.335; and

(2) Not more than the lesser of—

(i) 0.9 V_D established under § 23.335; or

(ii) 0.9 times the maximum speed shown under § 23.251.

(b) The maximum structural cruising speed V_{NO} must be established so that it is—

(1) Not less than the minimum value of V_C allowed under § 23.335; and

(2) Not more than the lesser of—

(i) V_C established under § 23.335; or

(ii) 0.89 V_{NE} established under paragraph (a) of this section.

(c) Paragraphs (a) and (b) of this section do not apply to turbine airplanes or to airplanes for which a design diving speed V_D/M_D is established under § 23.335(b)(4). For those airplanes, a maximum operating limit speed (V_{MO}/M_{MO} airspeed or Mach number, whichever is critical at a particular altitude) must be established as a speed that may not be deliberately exceeded in any regime of flight (climb, cruise, or descent) unless a higher speed is authorized for flight test or pilot training operations. V_{MO}/M_{MO} must be established so that it is not greater than the design cruising speed V_C/M_C and so that it is sufficiently below V_D/M_D and the maximum speed shown under § 23.251 to make it highly improbable that the latter speeds

§ 23.1507 [Operating maneuvering speed.

[The maximum operating maneuvering speed, V_O, must be established as an operating limitation. V_O is a selected speed that is not greater than $V_S\sqrt{n}$ established in § 23.335(c).]

[(Amdt. 23–45, Eff. 9/7/93)]

§ 23.1511 Flap extended speed.

(a) The flap extended speed V_{FE} must be established so that it is—

(1) Not less than the minimum value of V_F allowed in §§ 23.345 and 23.457; and

(2) Not more than the lesser of—

(i) V_F established under § 23.345; or

(ii) V_F established under § 23.457.

(b) Additional combinations of flap setting, airspeed, and engine power may be established if the structure has been proven for the corresponding design conditions.

§ 23.1513 Minimum control speed.

The minimum control speed V_{MC}, determined under § 23.149, must be established as an operating limitation.

§ 23.1519 Weight and center of gravity.

The weight and center of gravity limitations determined under § 23.23 must be established as operating limitations.

§ 23.1521 Powerplant limitations.

(a) *General.* [The powerplant limitations prescribed in this section must be established so that (for reciprocating engines);

(3) The maximum allowable gas temperature (for turbine engines);

(4) The time limit for the use of the power or thrust corresponding to the limitations established in paragraphs (b)(1) through (3) of this section; and

(5) If the time limit in paragraph (b)(4) of this section exceeds two minutes, the maximum allowable cylinder head (as applicable), liquid coolant, and oil temperatures.

(c) *Continuous operation.* The continuous operation must be limited by—

(1) The maximum rotational speed;

(2) The maximum allowable manifold pressure (for reciprocating engines);

(3) The maximum allowable gas temperature (for turbine engines); and

(4) The maximum allowable cylinder head, oil, and liquid coolant temperatures.

(d) *Fuel grade or designation.* The minimum fuel grade (for reciprocating engines), or fuel designation (for turbine engines), must be established so that it is not less than that required for the operation of the engines within the limitations in paragraphs (b) and (c) of this section.

(e) *Ambient temperature.* For turbine engines, ambient temperature limitations (including limitations for winterization installations if applicable) must be established as the maximum ambient atmospheric temperature at which compliance with the cooling provisions of §§ 23.1041 through 23.1047 is shown.

(Amdt. 23–21, Eff. 3/1/78); [(Amdt. 23–45, Eff. 9/7/93)]

[§ 23.1522 Auxiliary power unit limitations.

[If an auxiliary power unit is installed, the limitations established for the auxiliary power unit must be specified in the operating limitations for the airplane.]

[(Amdt. 23–45, Eff. 9/7/93)]

(2) Collision avoidance,

(3) Navigation,

(4) Communications,

(5) Operation and monitoring of all essential airplane systems,

(6) Command decisions, and

(7) The accessibility and ease of operation of necessary controls by the appropriate crewmember during all normal and emergency operations when at the crewmember flight station.

(b) The accessibility and ease of operation of necessary controls by the appropriate crewmember; and

(c) The kinds of operation authorized under § 23.1525.

(Amdt. 23–21, Eff. 3/1/78); (Amdt. 23–34, Eff. 2/17/87)

§ 23.1524 Maximum passenger seating configuration.

The maximum passenger seating configuration must be established.

(Amdt. 23–10, Eff. 3/13/71)

§ 23.1525 Kinds of operation.

[The kinds of operation authorized (e.g., VFR, IFR, day or night) and the meteorological conditions (e.g., icing) to which the operation of the airplane is limited or from which it is prohibited, must be established appropriate to the installed equipment.]

[(Amdt. 23–45, Eff. 9/7/93)]

§ 23.1527 Maximum operating altitude.

(a) [The maximum altitude up to which operation is allowed, as limited by flight, structural, powerplant, functional or equipment characteristics, must be established.

(b) [A maximum operating altitude limitation of not more than 25,000 feet must be established for

Continued Airworthiness in accordance with appendix G to this part that are acceptable to the Administrator. The instructions may be incomplete at type certification if a program exists to ensure their completion prior to delivery of the first airplane or issuance of a standard certificate of airworthiness, whichever occurs later.

(Amdt. 23–8, Eff. 2/5/70); (Amdt. 23–26, Eff. 10/14/80)

MARKINGS AND PLACARDS

§ 23.1541 General.

(a) The airplane must contain—

(1) The markings and placards specified in §§ 23.1545 through 23.1567; and

(2) Any additional information, instrument markings, and placards required for the safe operation if it has unusual design, operating, or handling characteristics.

(b) Each marking and placard prescribed in paragraph (a) of this section—

(1) Must be displayed in a conspicuous place; and

(2) May not be easily erased, disfigured, or obscured.

(c) For airplanes which are to be certificated in more than one category—

(1) The applicant must select one category upon which the placards and markings are to be based; and

(2) The placards and marking information for all categories in which the airplane is to be certificated must be furnished in the Airplane Flight Manual.

(d) [Deleted]

(Amdt. 23–13, Eff. 10/23/72); (Amdt. 23–21, Eff. 3/1/78)

§ 23.1543 Instrument markings: general.

For each instrument—

(a) When markings are on the cover glass of the instrument, there must be means to maintain marks located at the corresponding indicated airspeeds.

(b) The following markings must be made:

(1) For the never-exceed speed V_{NE}, a radial red line.

(2) For the caution range, a yellow arc extending from the red line specified in paragraph (b)(1) of this section to the upper limit of the green arc specified in paragraph (b)(3) of this section.

(3) For the normal operating range, a green arc with the lower limit at V_{S1} with maximum weight and with landing gear and wing flaps retracted, and the upper limit at the maximum structural cruising speed V_{NO} established under § 23.1505(b).

(4) For the flap operating range, a white arc with the lower limit at V_{SO} at the maximum weight and the upper limit at the flaps-extended speed V_{FE} established under § 23.1511.

(5) For the one-engine-inoperative best rate of climb speed, V_Y, a blue sector extending from the V_Y speed at sea level to the V_Y speed at—

(i) An altitude of 5,000 feet, if the one-engine-inoperative best rate of climb at that altitude is less than, 100 feet per minute, or

(ii) The highest 1,000-foot altitude (at or above 5,000 feet) at which the one-engine-inoperative best rate of climb is 100 feet per minute or more.

Each side of the sector must be labeled to show the altitude for the corresponding V_Y.

(6) For the minimum control speed (one-engine-inoperative) V_{MC}, a red radial line.

(c) If V_{NE} or V_{NO} vary with altitude, there must be means to indicate to the pilot the appropriate limitations throughout the operating altitude range.

(d) Paragraphs (b)(1) through (b)(3) and paragraph (c) of this section do not apply to aircraft for which a maximum operating speed V_{MO}/M_{MO} is established under § 23.1505(c). For those aircraft there must either be a maximum allowable airspeed indication showing the variation of V_{MO}/M_{MO} with altitude or compressibility limitations (as appropriate), or a radial red line marking for V_{MO}/M_{MO} must be made at lowest value of V_{MO}/M_{MO} estabdirection indicator.

(b) The placard must show the calibration of the instrument in level flight with the engines operating.

(c) The placard must state whether the calibration was made with radio receivers on or off.

(d) Each calibration reading must be in terms of magnetic headings in not more than 30° increments.

(e) If a magnetic nonstabilized direction indicator can have a deviation of more than 10° caused by the operation of electrical equipment, the placard must state which electrical loads, or combination of loads, would cause a deviation of more than 10° when turned on.

(Amdt. 23–20, Eff. 9/1/77)

§ 23.1549 [Powerplant and auxiliary power unit instruments.

[For each required powerplant and auxiliary power unit instrument, as appropriate to the type of instruments—]

(a) Each maximum and, if applicable, minimum safe operating limit must be marked with a red radial or a red line;

(b) Each normal operating range must be marked with a green arc or green line, not extending beyond the maximum and minimum safe limits;

(c) Each takeoff and precautionary range must be marked with a yellow arc or a yellow line; and

(d) [Each engine, auxiliary power unit, or propeller range that is restricted because of excessive vibration stresses must be marked with red arcs or red lines.]

(Amdt. 23–17, Eff. 2/1/77); (Amdt. 23–28, Eff. 4/28/82); [(Amdt. 23–45, Eff. 9/7/93)]

§ 23.1551 Oil quantity indicator.

Each oil quantity indicator must be marked in sufficient increments to indicate readily and accurately the quantity of oil.

§ 23.1555 Control markings.

(a) Each cockpit control, other than primary flight controls and simple push button type starter switches, must be plainly marked as to its function and method of operation.

(b) Each secondary control must be suitably marked.

(c) For powerplant fuel controls—

(1) Each fuel tank selector control must be marked to indicate the position corresponding to each tank and to each existing cross feed position;

(2) If safe operation requires the use of any tanks in a specific sequence, that sequence must be marked on or near the selector for those tanks;

(3) The conditions under which the full amount of usable fuel in any restricted usage fuel tank can safely be used must be stated on a placard adjacent to the selector valve for that tank; and

(4) Each valve control for any engine of a multiengine airplane must be marked to indicate the position corresponding to each engine controlled.

(d) Usable fuel capacity must be marked as follows:

(1) For fuel systems having no selector controls, the usable fuel capacity of the system must be indicated at the fuel quantity indicator.

(2) For fuel systems having selector controls, the usable fuel capacity available at each selector control position must be indicated near the selector control.

(e) For accessory, auxiliary, and emergency controls—

(1) If retractable landing gear is used, the indicator required by § 23.729 must be marked so that the pilot can, at any time, ascertain that the wheels are secured in the extreme positions; and

(2) Each emergency control must be red and must be marked as to method of operation.

(Amdt. 23–21, Eff. 3/1/78)

placard stating the lesser weight must be permanently attached to the seat structure.

(c) *Fuel and oil filler openings.* The following apply:

(1) [Fuel filler openings must be marked at or near the filler cover with—

(i) For reciprocating engine-powered airplanes—

(A) The word "Avgas"; and

(B) The minimum fuel grade.

(ii) For turbine engine-powered airplanes—

(A) The words "Jet Fuel"; and

(B) The permissible fuel designations, or references to the Airplane Flight Manual (AFM) for permissible fuel designations.

(iii) For pressure fueling systems, the maximum permissible fueling supply pressure and the maximum permissible defueling pressure.

(2) Oil filler openings must be marked at or near the filler cover with the word "Oil" and the permissible oil designations, or references to the Airplane Flight Manual (AFM) for permissible oil designations.

(3) Coolant filler openings must be marked at or near the filler cover with the word "Coolant".]

(d) *Emergency exit placards.* Each placard and operating control for each emergency exit must be red. A placard must be near each emergency exit control and must clearly indicate the location of that exit and its method of operation.

(e) The system voltage of each direct current installation must be clearly marked adjacent to its external power connection.

(f) *Unusable fuel.* [Removed]

(Amdt. 23–7, Eff. 9/14/69); (Amdt. 23–14, Eff. 12/20/73); (Amdt. 23–18, Eff. 5/2/77); (Amdt. 23–23, Eff. 12/11/78); [(Amdt. 23–45, Eff. 9/7/93)]

§ 23.1559 Operating limitations placard.

(a) There must be a placard in clear view of the pilot stating—

(1) For airplanes certificated in one category:

The markings and placards installed in this airplane contain operating limitations which must be complied with when operating this airplane in the ________ category. (Insert category.) Other operating limitations which must be complied with when operating this airplane in this category or in the ________ category are contained in the Airplane Flight Manual. (Insert category or categories.)

(b) There must be a placard in clear view of the pilot that specifies the kind of operations (such as VFR, IFR, day, or night) and the meteorological conditions (such as icing conditions) to which the operation of the airplane is limited, or from which it is prohibited, by the equipment installed.

(Amdt. 23–13, Eff. 10/23/72); (Amdt. 23–21, Eff. 3/1/78)

§ 23.1561 Safety equipment.

(a) Safety equipment must be plainly marked as to method of operation.

(b) Stowage provisions for required safety equipment must be marked for the benefit of occupants.

§ 23.1563 Airspeed placards.

There must be an airspeed placard in clear view of the pilot and as close as practicable to the airspeed indicator: This placard must list—

(a) [The operating maneuvering speed, V_O; and]

(b) The maximum landing gear operating speed, V_{LO}.

(Amdt. 23–3, Eff. 11/11/65); (Amdt. 23–7, Eff. 9/14/69); [(Amdt. 23–45, Eff. 9/7/93)]

§ 23.1567 Flight maneuver placard.

(a) For normal category airplanes, there must be a placard in front of and in clear view of the pilot stating: "No acrobatic maneuvers, including spins, approved."

(b) For utility category airplanes, there must be—

(1) A placard in clear view of the pilot stating: "Acrobatic maneuvers are limited to the follow-

ommended entry airspeed for each). If inverted flight maneuvers are not approved, the placard must bear a notation to this effect.

(Amdt. 23–13, Eff. 10/23/72); (Amdt. 23–21, Eff. 3/1/78)

AIRPLANE FLIGHT MANUAL AND APPROVED MANUAL MATERIAL

§ 23.1581 General.

(a) *Furnishing information.* An Airplane Flight Manual must be furnished with each airplane, and it must contain the following:

(1) Information required by §§ 23.1583 through 23.1589.

(2) Other information that is necessary for safe operation because of design, operating, or handling characteristics.

(b) *Approved information.*

(1) Except as provided in paragraph (b)(2) of this section, each part of the Airplane Flight Manual containing information prescribed in §§ 23.1583 through 23.1589 must be approved, segregated, identified and clearly distinguished from each unapproved part of that Airplane Flight Manual.

(2) The requirements of paragraph (b)(1) of this section do not apply if the following is met:

(i) Each part of the Airplane Flight Manual containing information prescribed in § 23.1583 must be limited to such information, and must be approved, identified, and clearly distinguished from each other part of the Airplane Flight Manual.

(ii) The information prescribed in § 23.1585 through 23.1589 must be determined in accordance with the applicable requirements of this part and presented in its entirety in a manner acceptable to the Administrator.

(3) Each page of the Airplane Flight Manual containing information prescribed in this section must be of a type that is not easily erased, disfigured, or misplaced, and is capable of being

[(f) *Revisions and amendments.* Each Airplane Flight Manual (AFM) must contain a means for recording the incorporation of revisions and amendments.]

(Amdt. 23–13, Eff. 10/23/72); (Amdt. 23–21, Eff. 3/1/78); (Amdt. 23–34, Eff. 2/17/87); [(Amdt. 23–45, Eff. 9/7/93)]

§ 23.1583 Operating limitations.

[Operating limitations determined during type certification must be stated, including the following:]

(a) *Airspeed limitations.* The following information must be furnished:

(1) Information necessary for the marking of the airspeed limits on the indicator as required in § 23.1545, and the significance of each of those limits and of the color coding used on the indicator.

(2) [The speeds V_{MC}, V_O, V_{LE}, and V_{LO}, if established, and their significance.]

(3) In addition, for commuter category airplanes—

(i) The maximum operating limit speed, V_{MO}/M_{MO} and a statement that this speed may not be deliberately exceeded in any regime of flight (climb, cruise, or descent) unless a higher speed is authorized for flight test or pilot training;

(ii) If an airspeed limitation is based upon compressibility effects, a statement to this effect and information as to any symptoms, the probable behavior of the airplane, and the recommended recovery procedures; and

(iii) The airspeed limits must be shown in terms of V_{MO}/M_{MO} instead of V_{NO} and V_{NE}.

(b) *Powerplant limitations.* The following information must be furnished:

(1) Limitations required by § 23.1521.

(2) Explanation of the limitations, when appropriate.

(3) Information necessary for marking the instruments required by §§ 23.1549 through 23.1553.

runway length within the range selected by the applicant may not exceed the weight at which—

(i) The all-engine-operating distance determined under § 23.59 or the accelerate-stop distance determined under § 23.55, whichever is greater, is equal to the available runway length;

(ii) The airplane complies with the one-engine-inoperative takeoff distance requirements of § 23.59; and

(iii) The airplane complies with the one-engine-inoperative takeoff and en route climb requirements of §§ 23.57 and 23.67.

(4) In addition, for commuter category airplanes, the maximum landing weight for each altitude, ambient temperature, and required landing runway length, within the range selected by the applicant. The maximum landing weights may not exceed:

(i) The weight at which the landing distance is determined under § 23.75; or

(ii) The weight at which compliance with § 23.77 is shown.

(d) *Center of gravity.* The established center of gravity limits must be furnished.

(e) *Maneuvers.* The following authorized maneuvers, appropriate airspeed limitations, and unauthorized maneuvers must be furnished as prescribed in this section.

(1) *Normal category airplanes.* For normal category airplanes, acrobatic maneuvers, including spins, are unauthorized. If the airplane has been shown to be "characteristically incapable of spinning" under § 23.221(d), a statement to this effect must be entered. Other normal category airplanes must be placarded against spins.

(2) *Utility category airplanes.* For utility category airplanes, authorized maneuvers shown in the type flight tests must be furnished, together with recommended entry speeds. No other maneuver is authorized. If the airplane has been shown to be "characteristically incapable of spinning" under § 23.221(d), a statement to this effect must be entered.

(3) *Acrobatic category airplanes.* For acrobatic category airplanes, the approved flight maneuvers

factors in g's, must be furnished.

(g) *Flight crew.* If a flight crew of more than one is required for safety, the number and functions of the minimum flight crew must be furnished.

(h) *Kinds of operation.* [A list of the kinds of operation to which the airplane is limited or from which it is prohibited under § 23.1525, and also a list of installed equipment that affects any operating limitation and identification as to the equipment's required operational status for the kinds of operation for which approval has been given.]

(i) [Reserved]

(j) [Reserved]

(k) *Maximum operating altitude.* The maximum aititude established under § 23.1527 must be furnished.

(l) *Maximum passenger seating configuration.* The maximum passenger seating configuration must be furnished.

[(m) *Allowable lateral fuel loading.* The maximum allowable lateral fuel loading differential must be furnished if less than the maximum possible.]

(Amdt. 23–7, Eff. 9/14/69); (Amdt. 23–10, Eff. 3/13/71); (Amdt. 23–21, Eff. 3/1/78); (Amdt. 23–23, Eff. 12/1/78); (Amdt. 23–34, Eff. 2/17/87); [(Amdt. 23–45, Eff. 9/7/93)]

§ 23.1585 Operating procedures.

(a) [For each airplane, information concerning normal, abnormal, and emergency procedures and other pertinent information necessary for safe operation and the achievement of the scheduled performance must be identified and segregated, including—

(1) The maximum demonstrated values of crosswind velocity for takeoff and landing and procedures and information pertinent to operations in crosswinds;

(2) The speeds, configurations, and procedures for making a normal takeoff and the subsequent climb;

(3) Procedure for abandoning a takeoff due to engine failure or other cause;

example, stalling); and

(7) For seaplanes and amphibians, water handling procedures and the demonstrated wave height.

[(b) For single-engine airplanes, the procedures, speeds, and configurations for a glide following an engine failure and subsequent forced landing.

(c) [For multiengine airplanes, the information must include—

(1) Procedures and speeds for continuing a takeoff following failure of the critical engine and the conditions under which takeoff can be safely continued, or a warning against attempting to continue the takeoff;

(2) Procedures, speeds, and configurations for continuing a climb following engine failure after takeoff or en route;

(3) Procedures, speeds, and configurations for making an approach and landing with one engine inoperative;

(4) Procedures, speeds, and configurations for making a go-around with one engine inoperative and the conditions under which the go-around can safely be executed, or a warning against attempting the go-around maneuver;

(5) Procedures for restarting engines in flight, including the effects of altitude, must be set forth in the Airplane Flight Manual (AFM); and

(6) The V_{SSE} determined in § 23.149.]

(d) For multiengine airplanes, information identifying each operating condition in which the fuel system independence prescribed in § 23.953 is necessary for safety must be furinished, together with instructions for placing the fuel system in a configuration used to show compliance with that section.

(e) For each airplane showing compliance with §§ 23.1353(g)(2) or (3), the operating procedures for disconnecting the battery from its charging source must be furnished.

(f) If the unusable fuel supply in any tank exceeds 5 percent of the tank capacity, or 1 gallon, whichever is greater, information must be furnished which indicates that when the fuel quantity indicator reads ''zero'' in level flight, any fuel remaining in the fuel tank cannot be used safely in flight.

23–34, Eff. 2/17/87); [(Amdt. 23–45, Eff. 9/7/93)]

§ 23.1587 Performance information.

[The following information must be furnished:

(a) [For normal, utility, and acrobatic category airplanes—

(1) The takeoff distance determined under § 23.51 and the kind of runway surface used in the tests.

(2) The climb gradient determined under §§ 23.65 and 23.77, with the associated airspeed, power, and the airplane configuration.

(3) The landing distance determined under § 23.75.

(4) The one engine inoperative en route climb/descent gradients determined under § 23.67 for multiengine airplanes.

(5) The calculated approximate effect on takeoff distance, landing distance, and climb performance for variations in—

(i) Altitude from sea level to 10,000 feet in a standard atmosphere and cruise configuration; and

(ii) Temperature, at those altitudes from 60°F below standard to 40°F above standard.

(b) [For skiplanes, a statement of the approximate reduction in climb performance may be used instead of complete new data for the skiplane configuration if—

(1) The landing gear is fixed in both the landplane and skiplane configurations;

(2) The climb performance is not critical; and

(3) The climb reduction in the skiplane configuration does not exceed 50 feet per minute.

(c) [For each airplane:

(1) Any loss of altitude more than 100 feet, or any pitch more than 30 degrees below level flight attitude, occurring during the recovery part of maneuvers prescribed in §§ 23.201(c) and 23.205, if applicable.

(2) The stalling speed, V_{SO}, at maximum weight.

(3) The stalling speed, V_{S1}, at maximum weight and with the landing gear and wing flaps

been shown.]

(d) *Commuter category airplanes.* In addition, for commuter category airplanes, the Airplane Flight Manual must contain at least the following performance information:

(1) Sufficient information so that the takeoff weight limits specified in § 23.1583 can be determined for all temperatures and altitudes within the operational limitations selected by the applicant;

(2) The conditions under which the performance information was obtained, including the airspeed at the 50-foot height used to determine the landing distance as required by § 23.75;

(3) The performance information (determined by extrapolation and computed for the range of weights between the maximum landing and maximum takeoff weights for—

(i) Climb in the landing configuration as determined by § 23.77; and

(ii) Landing distance as determined by § 23.75;

(4) Procedures information established in accordance with the limitations and other information for safe operation of the airplane in the form of recommended procedures;

instrumentation errors, including the indicator, are accounted for in the flight manual data.

(Amdt. 23–7, Eff. 9/14/69); (Amdt. 23–21, Eff. 3/1/78); (Amdt. 23–28, Eff. 4/28/82); (Amdt. 23–34, Eff. 2/17/87); (Amdt. 23–39, Eff. 5/2/90); [(Amdt. 23–45, Eff. 9/7/93)]

§ 23.1589 Loading information.

The following loading information must be furnished:

(a) [The weight and location of each item of equipment that can be easily removed, relocated, or replaced and that is installed when the airplane was weighed under the requirement of § 23.25.]

(b) Appropriate loading instructions for each possible loading condition between the maximum and minimum weights determined under § 23.25 that can result in a center of gravity beyond—

(1) The extremes selected by the applicant;

(2) The extremes within which the structure is proven; or

(3) The extremes within which compliance with each functional requirement is shown.

[(Amdt. 23–45, Eff. 9/7/93)]

where—

$F_{H\,max}$ = maximum rearward horizontal force acting on the wheel (in pounds);

r_e = effective rolling radius of wheel under impact based on recommended operating tire pressure (which may be assumed to be equal to the rolling radius under a static load of $n_j W_e$) in feet;

I_w = rotational mass moment of inertia of rolling assembly (in slug feet);

V_H = linear velocity of airplane parallel to ground at instant of contact (assumed to be 1.2 V_{SO}, in feet per second);

V_C = peripheral speed of tire, if prerotation is used (in feet per second) (there must be a positive means of pre-rotation before pre-rotation may be considered);

n = effective coefficient of friction (0.80 may be used);

$F_{V\,max}$ = maximum vertical force on wheel (pounds = $n_j W_e$, where W_e, and n_j are defined in § 23.725;

t_z = time interval between ground contact and attainment of maximum vertical force on wheel (seconds). However, if the value of $F_{V\,max}$, from the above equation exceeds 0.8 $F_{V\,max}$, the latter value must be used for $F_{H\,max}$.)

rational or conservative allowances must be made to compensate for these variations. On most landing gears, the time for wheel spin-up will be less than the time required to develop maximum vertical load factor for the specified rate of descent and forward velocity. For exceptionally large wheels, a wheel peripheral velocity equal to the ground speed may not have been attained at the time of maximum vertical gear load. However, as stated above, the drag spinup load need not exceed 0.8 of the maximum vertical loads.

[(c) Dynamic spring-back of the landing gear and adjacent structure at the instant just after the wheels come up to speed may result in dynamic forward acting loads of considerable magnitude. This effect must be determined, in the level landing condition, by assuming that the wheel spin-up loads calculated by the methods of this appendix are reversed. Dynamic spring-back is likely to become critical for landing gear units having wheels of large mass or high landing speeds.]

[(Amdt. 23–45, Eff. 9/7/93)]

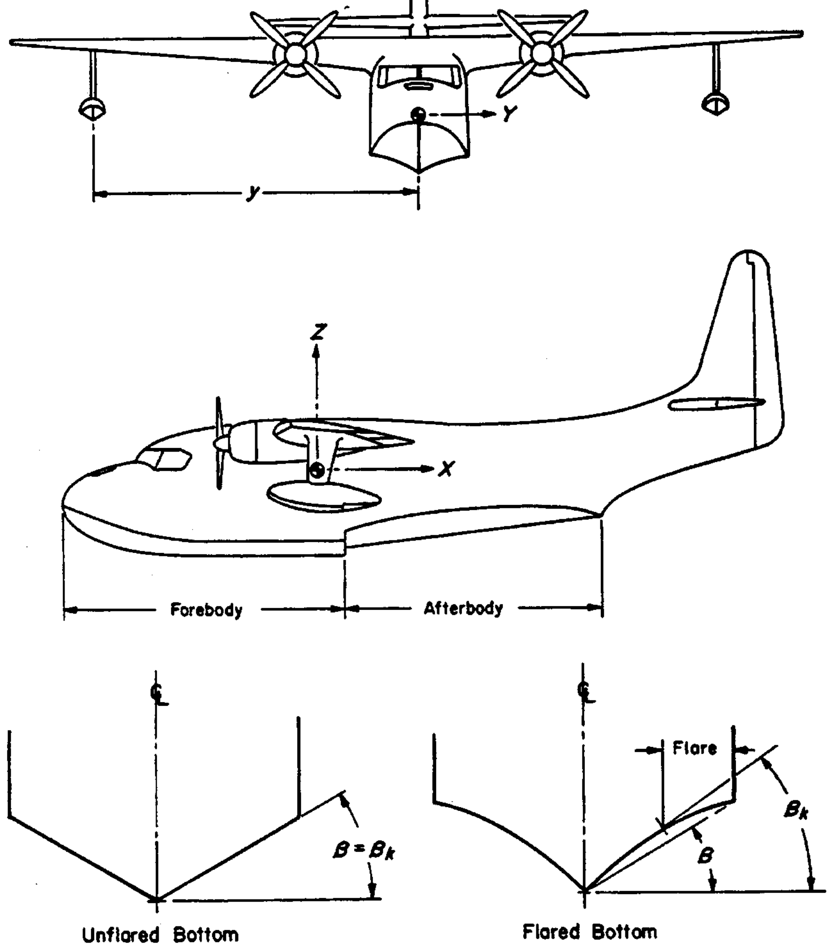


FIGURE 1. Pictorial definition of angles, dimensions, and directions on a seaplane.

FIGURE 2. Hull station weighing factor.

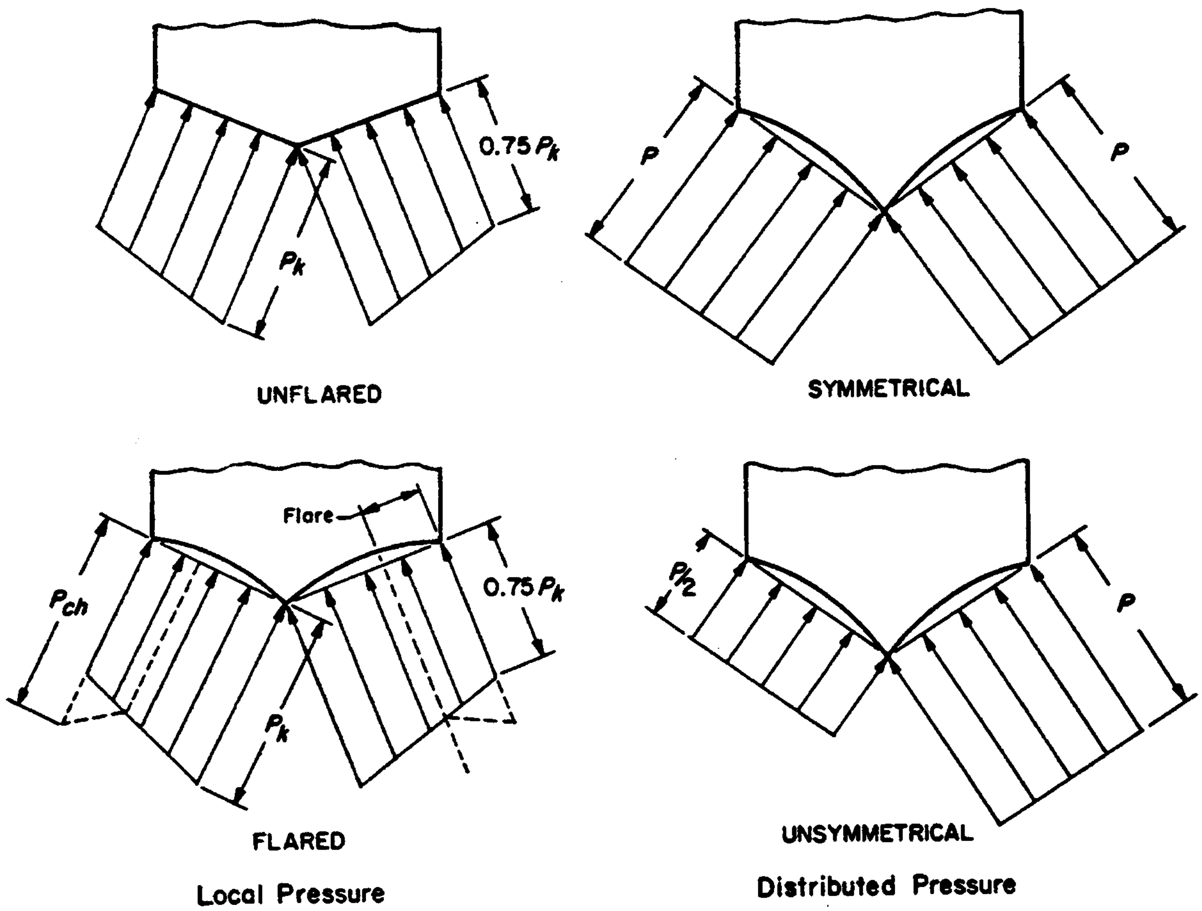


FIGURE 3. Transverse pressure distributions.

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